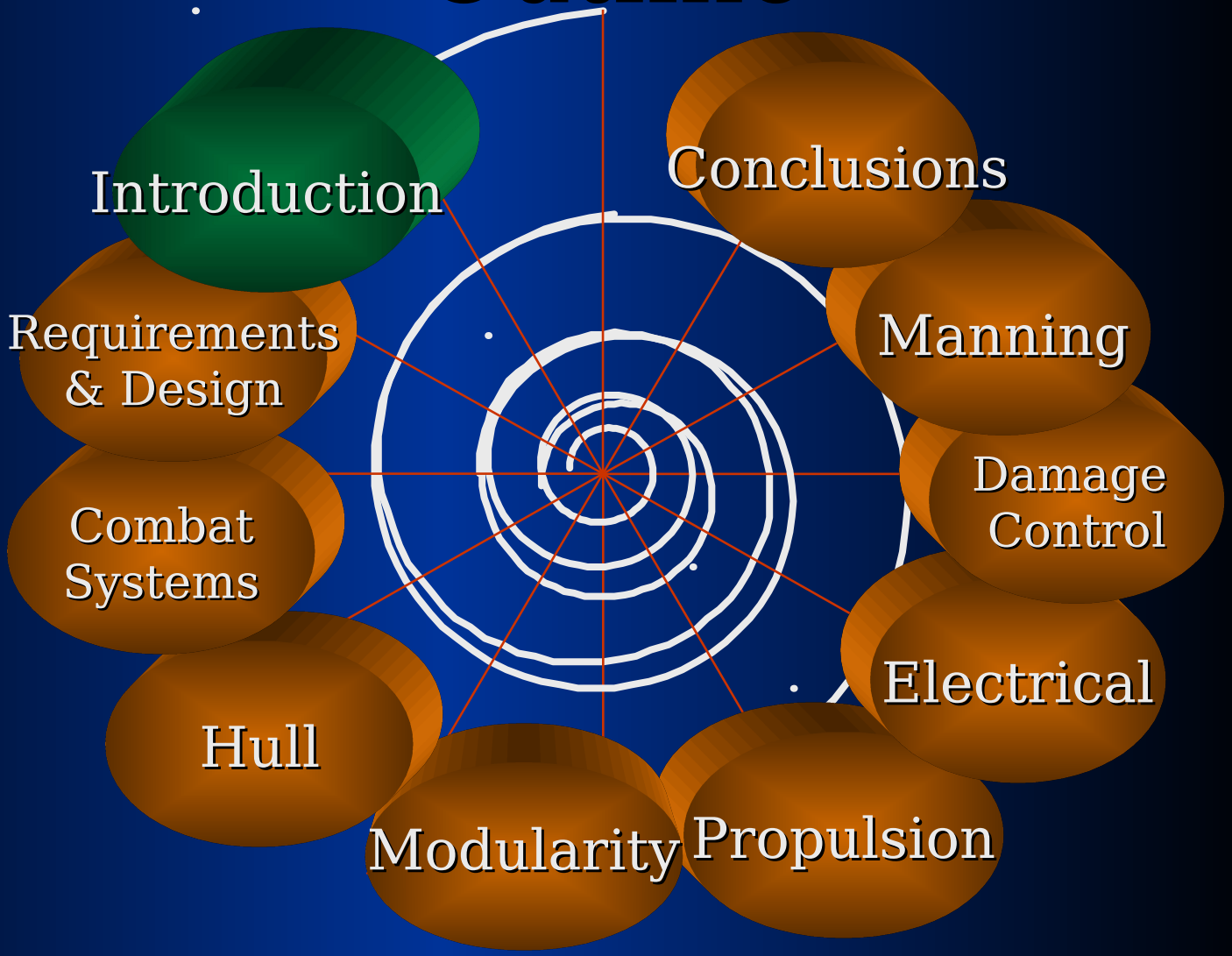
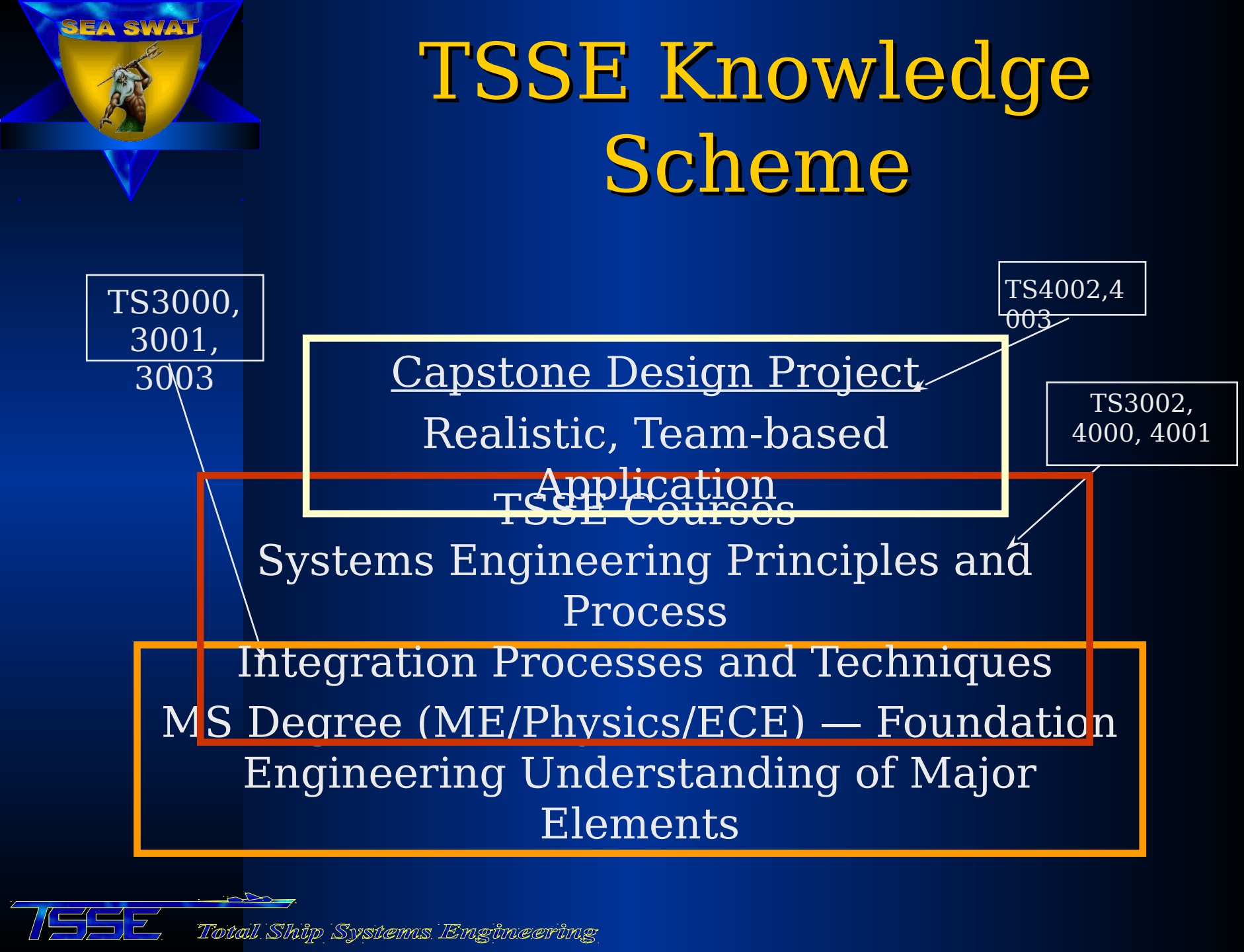
SEA SWAT
Sea Base Defense LCS

Total Ship Systems Engineering 2003

TSSE Presentation Outline



TSSE Knowledge Scheme



2003 TSSE Faculty and Team

Faculty Members

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Team Members

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LT Jake Didoszak, USN

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LTJG Zafer Elcin, Turkish Navy

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LT Scott Lunt, USN

LT Freddy Santos, USN

The Taskers

- Systems Engineering Analysis - Initial Requirements Document (SEA-IRD)
- TSSE Faculty Capstone Design Project Guidance
- N7 Preliminary Design Initial Requirements Document (N7 PD-IRD)

Sea Power 21

Sea Shield

- Force Protection
- Surface Warfare
- Under Sea Warfare
- Theater Air and Missile Defense

Sea Strike

- Strike
- Fire Support
- Maneuver
- Strategic Deterrence

Sea Basing

- Deploy and Employ
- Provide Integrated Joint Logistics
- Pre-Position Joint Assets Afloat

FORCEnet

- Intel, Surveillance, Reconnaissance
- Common Operational and Tactical Pictures
- Networks

Sea Shield

Force Protection

- Protect Against SOF and Terrorist Threats
- Mitigate Effects of CBRNE

Surface Warfare

- Provide Defense Against Surface Threats
- Conduct Offensive Operations against Surface Threats

Under Sea Warfare

- Neutralize Submarine Threats in the Littorals
- Provide Self-Defense Against Subsurface Threats
- Neutralize Open Ocean Submarine Threats
- Counter Minefields from Deep to Shallow Water
- Breach Minefields, Obstacles, and Barriers from VSW to the Beach Exit Zone
- Conduct Mining Operations

Theater Air and Missile Defense

- Provide Defense Against Air and Missile Threats
- Provide Maritime Air and Missile Defense
- Provide Overland Air and Missile Defense
- Conduct Sea-Based Missile Defense

Sea Basing

Deploy and Employ

- Close the Force & Maintain Mobility
- Provide at Sea Arrival and Assembly
- Allow Selective Offload
- Reconstitute and Regenerate at Sea

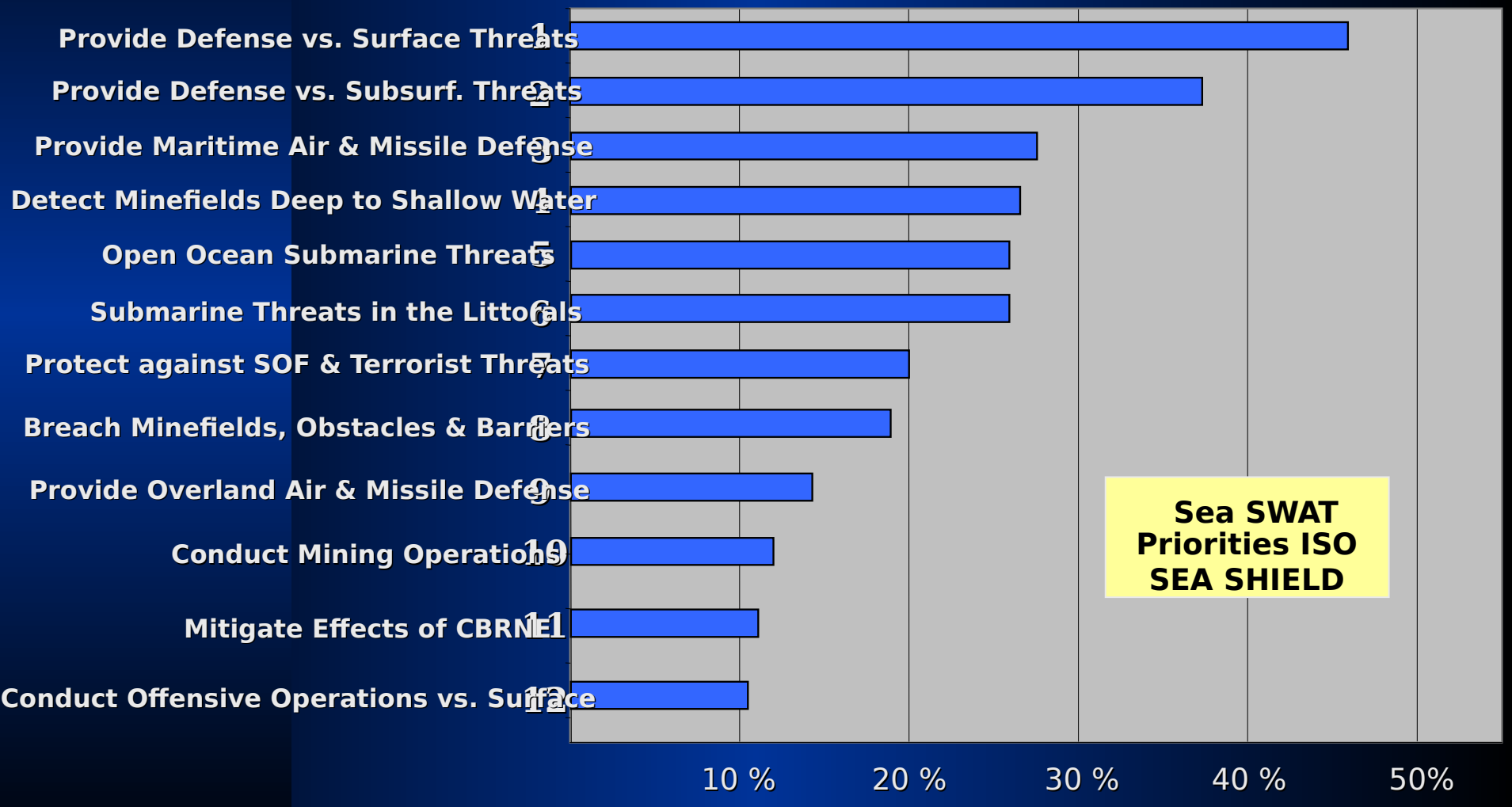
Provide Integrated Joint Logistics

- Provide Sustainment for Operations at Sea
- Provide Sustainment for Operations Ashore
- Provide Focused Logistics
- Provide Shipboard and Mobile Maintenance
- Provide Force Medical Services
- Provide Advanced Base Support

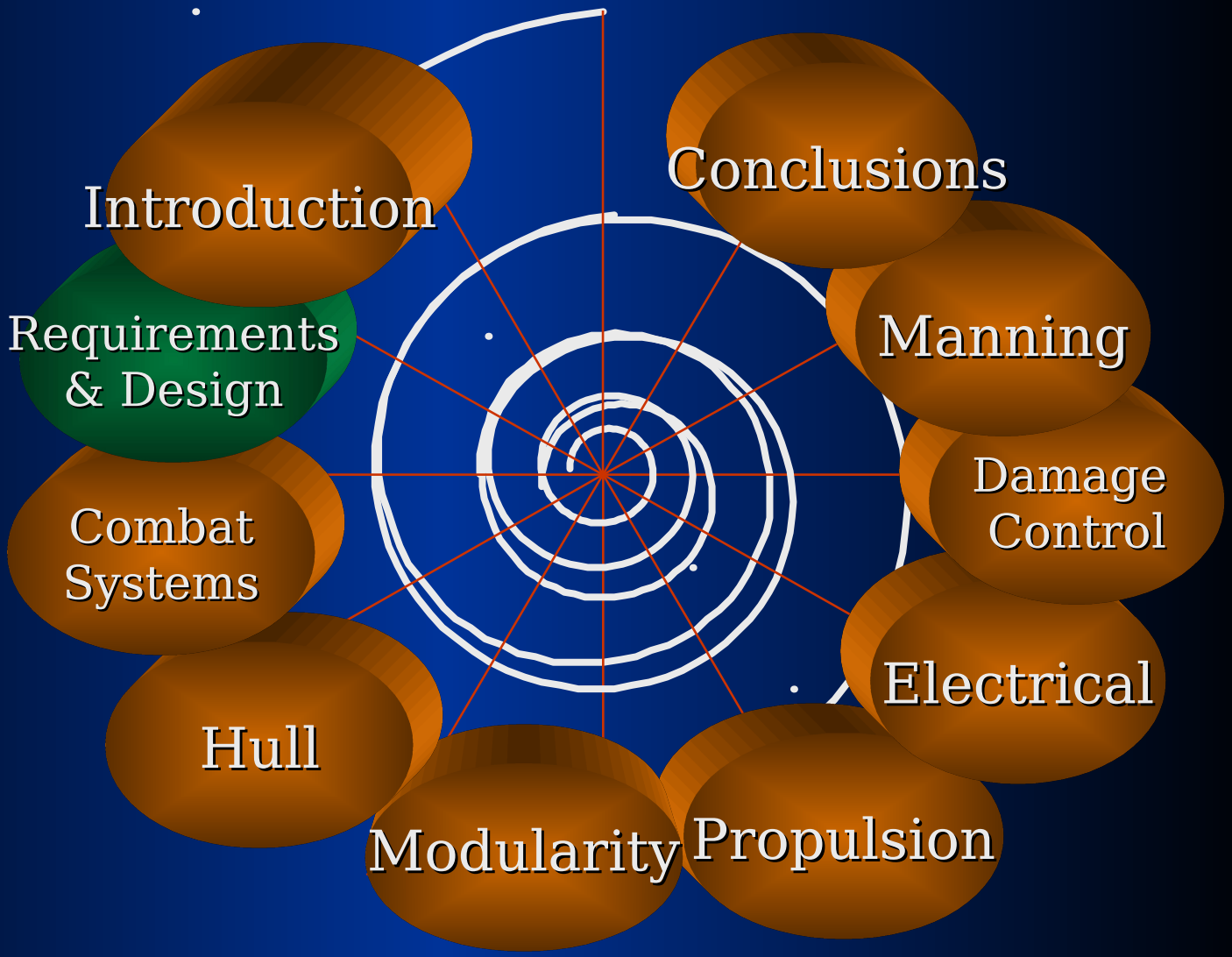
Pre-Position Joint Assets Afloat

- Integrate and Support Joint Personnel and Equipment
- Provide Afloat C2 Physical infrastructure
- Provide AFSB Capability for Joint Operations

SEA SWAT Priorities



Requirements



Design Project Guidance

…to produce a design for a ship or group of ships to protect the ships of the Sea Base while in the operating area

and

…protection of the airborne assets moving between Sea Base and the objective

and

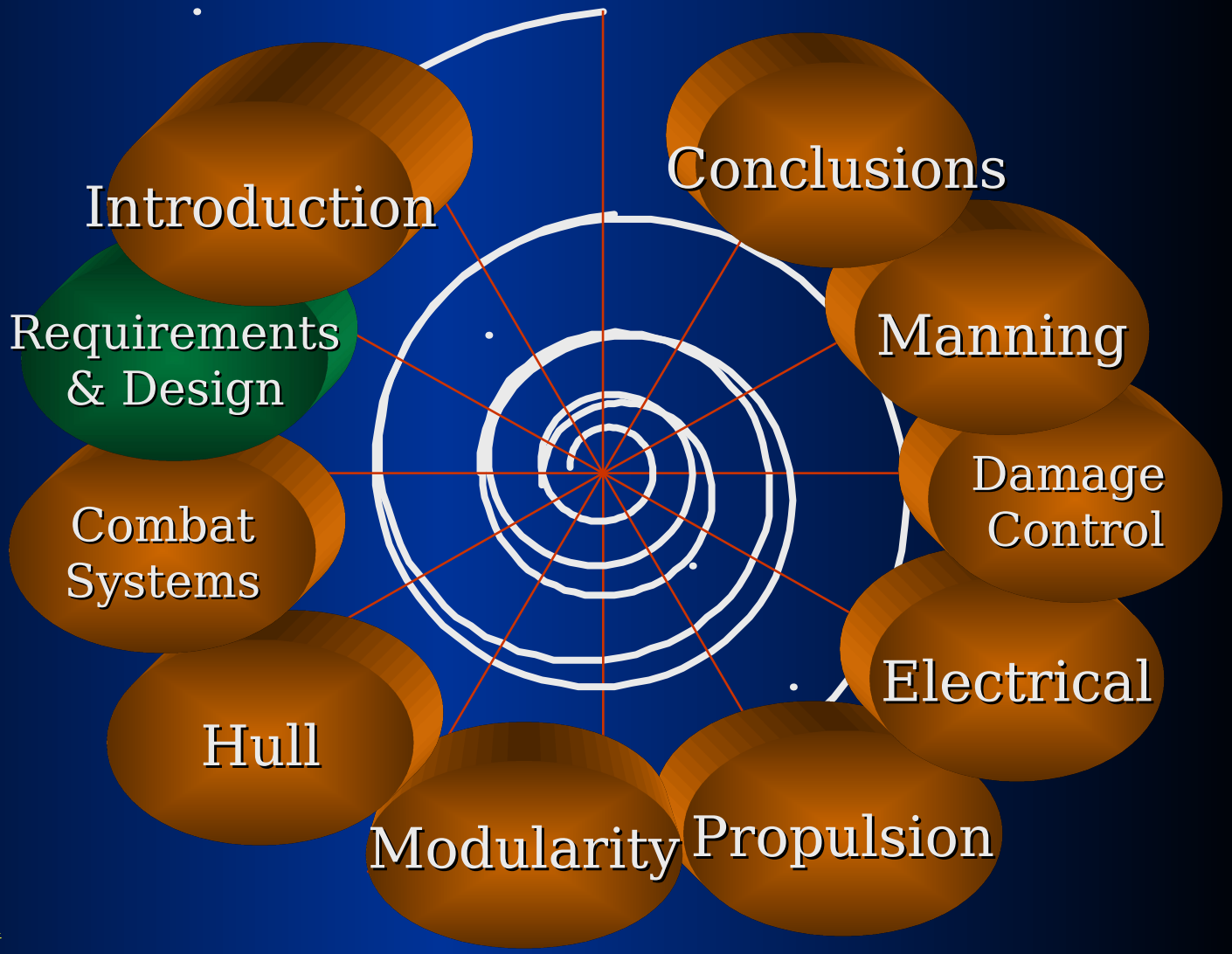
…protection of the surface assets moving between Sea Base and the beach

Requirements Overview

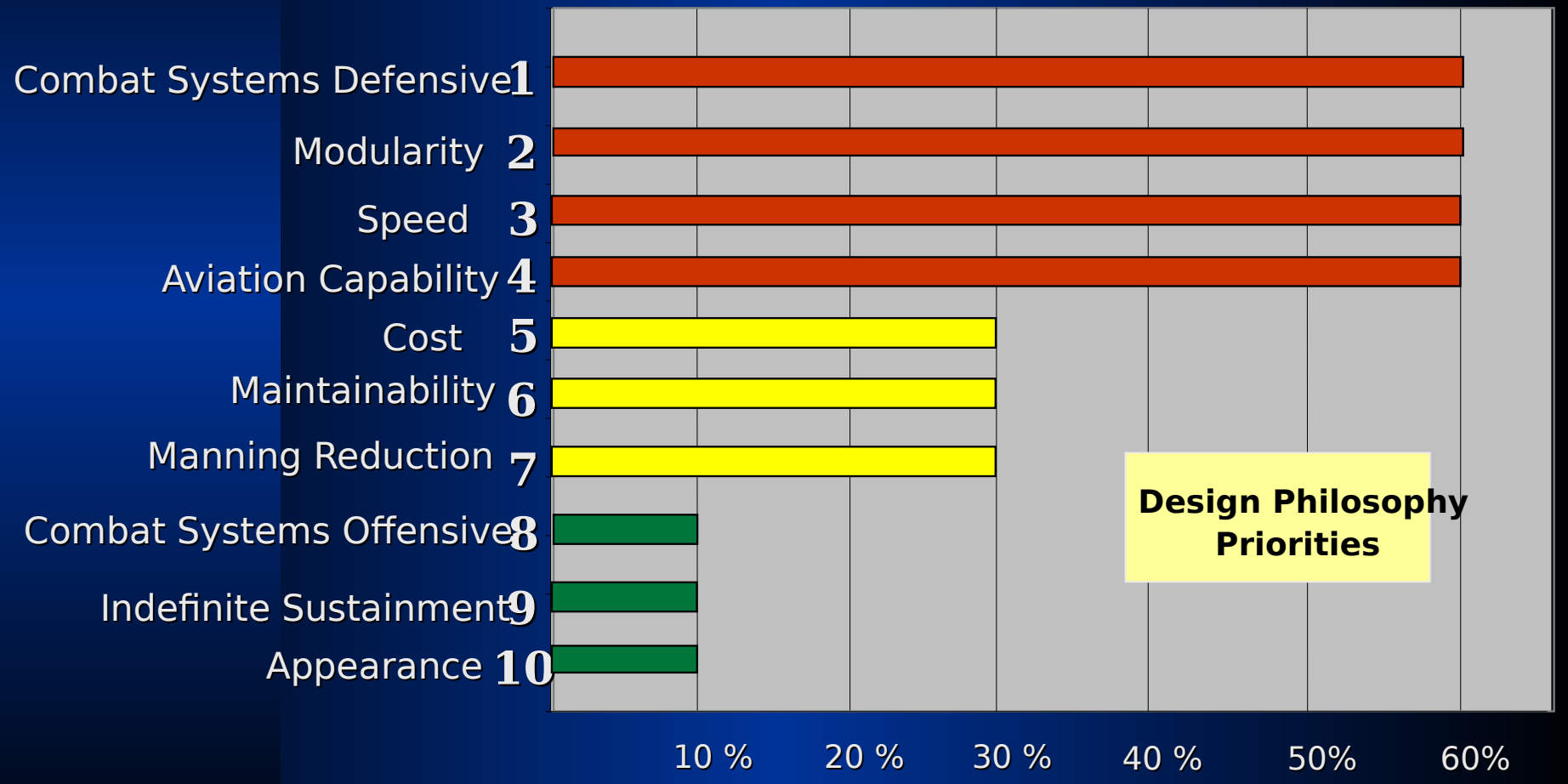
- Protect the Sea Base
- Operate in Deep to Very Shallow Water
- Operate at 35 knots
- AW, SUW, USW/MIW capable
- Reduced Manning implemented
- Modular Design

SEA SWAT

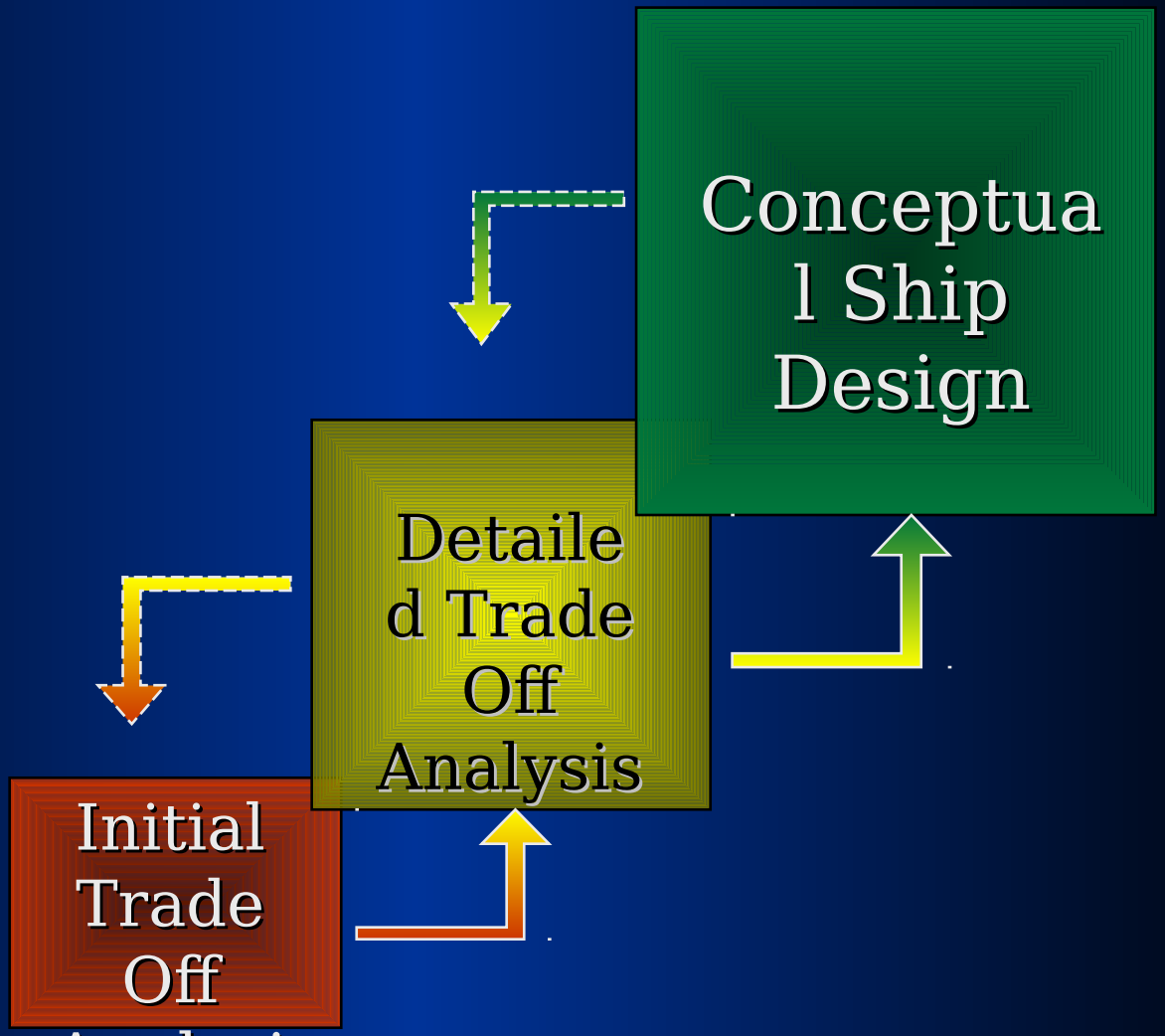
Design Philosophy



Overall Design Philosophy



Design Process



Courses of Action

- COA #1: Single Ship Concept
- COA #2: Two-Ship Concept
- Trade-off analysis conducted to determine which COA better meets requirements

Trade-off Analysis Priorities

- **Operational Flexibility** (10%)
- **Operational Capability** (10%)
- **Operational Availability** (10%)
- **Cost** (15%)
- **Space Availability** (15%)
- **Acquisition** (40%)

(%) Weight of each priority

Cost Analysis*

Characteristics	Single Ship (SUW, AAW, & USW/MIW)	Two Ship (SUW,USW/MIW & SUW/AAW)
Length	258 ft	249 ft
Beam	52 ft	50 ft
Draft	19.2 ft	18.5 ft
Power	39500 hp	36800 hp
Displacement	1626 LT	1454 LT
Est. Cost of Hull	$450 M	$425 M
Est. Cost of Combat Systems	$225 M	$212.5 M
Total Est. Acquisition	$675 M	$637.5 M x 2 = $1275 M

*Based on MAPC spreadsheet

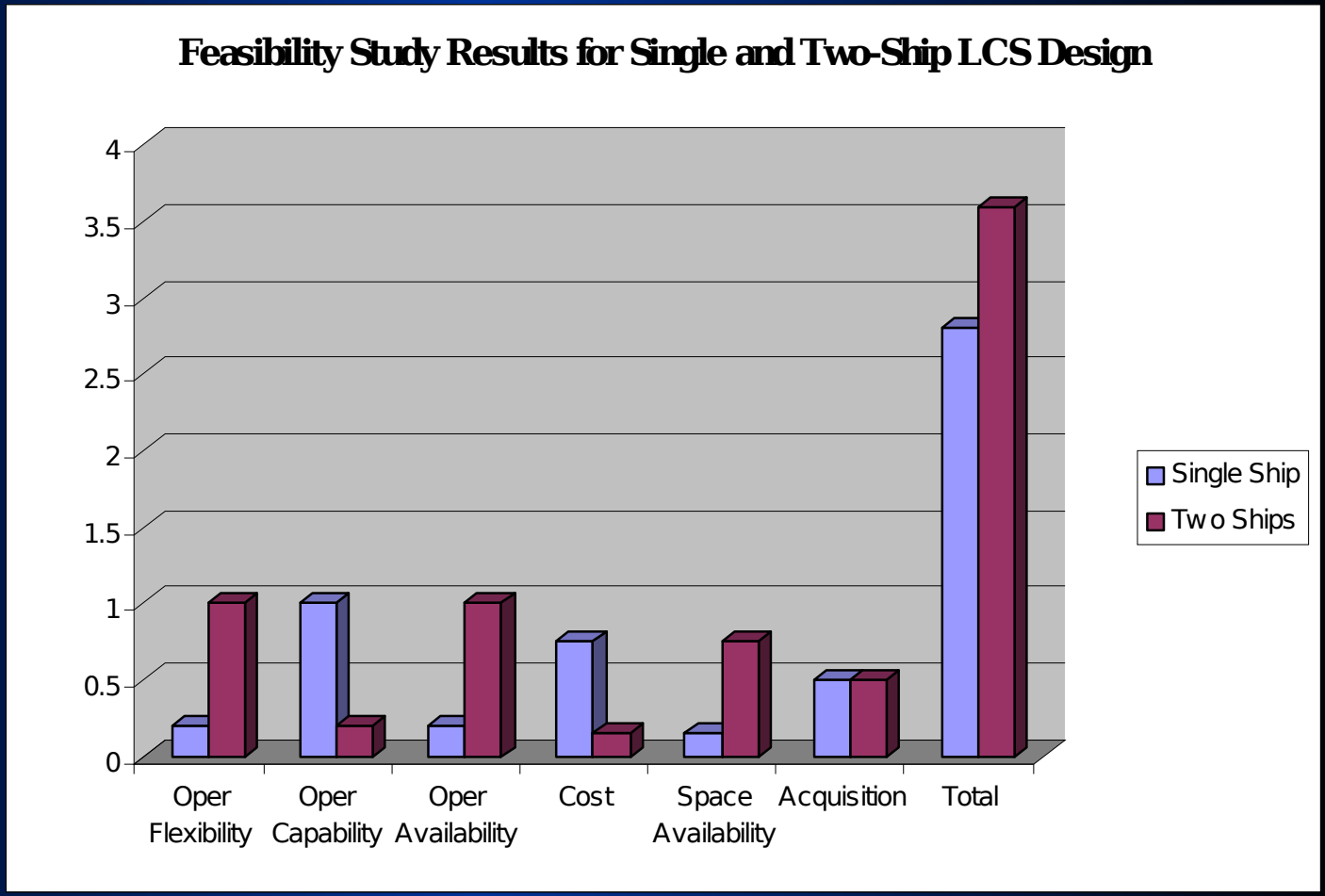
Total Ship Systems Engineering

Single Ship vs. Two Ships

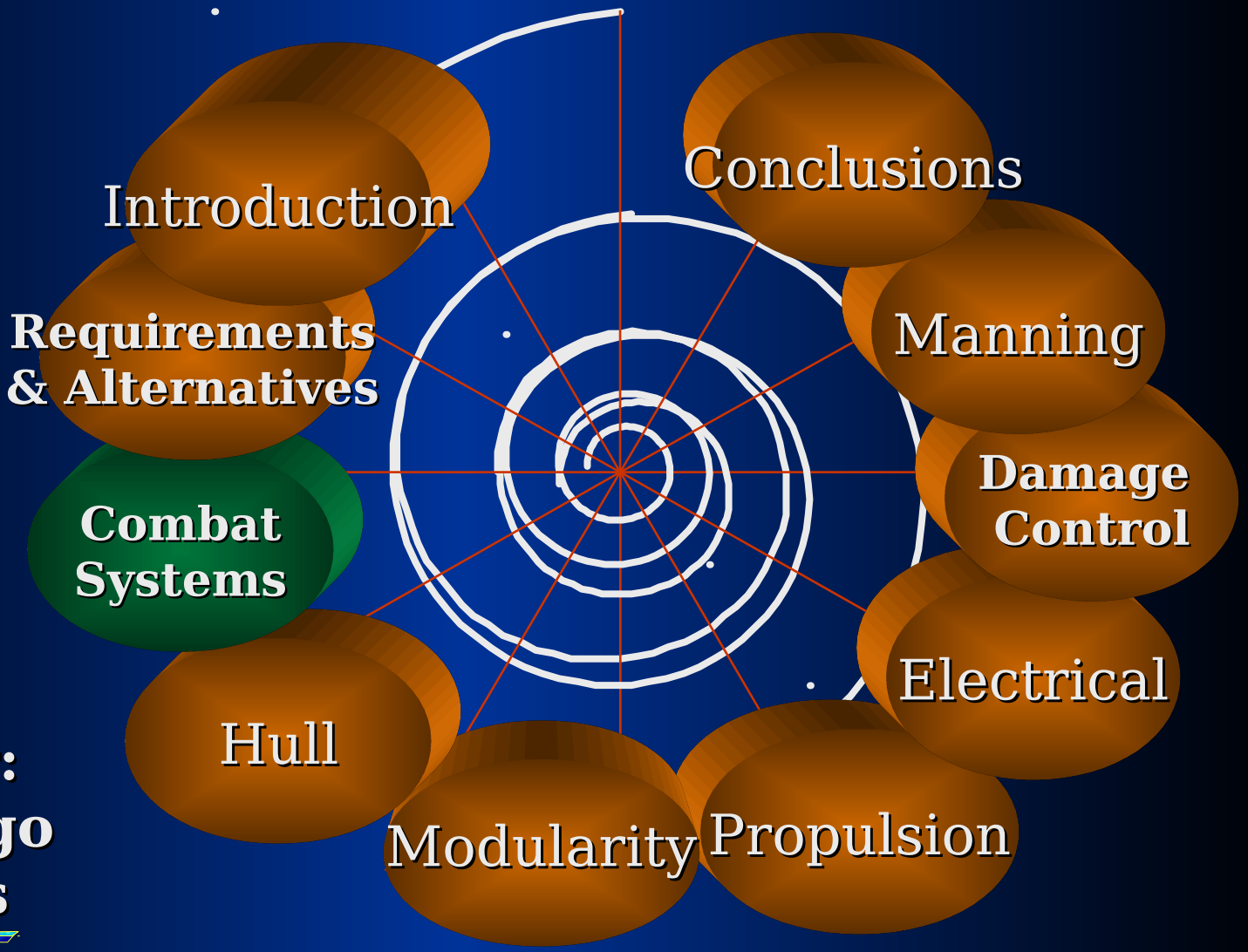
Priority	Single Ship Design	Two Ship Design
Operational Flexibility	.2	1
Operational Capability	1	.2
Operational Availability	.2	1
Cost	.75	.15
Space Availability	.15	.75
Acquisition	.5	.5
Total*	2.8	3.6

*Sum of the product of each priority weight and ranking

Single Ship vs. Two Ships



Combat Systems



Next Speaker: LT Rodrigo Cabezas

Threats

Sea Base States

State I – Staging / Buildup (Op Area)

- ASCM
- Small boats
- Unconventional ships/boats
- Submarines/UUVs
- Mines

State II – Ship-to-Shore / Ship-to-Obj. Maneuver

- Small boats
- Mines
- SAMs
- Unguided munitions
- Aircraft/UAVs

Threats (cont'd)

Sea Base States

State III – Sustainment

- ASCM
- Mines
- Unconventional ships/boats
- SAMs
- Aircraft/UAVs

Initial Combat Needs Analysis

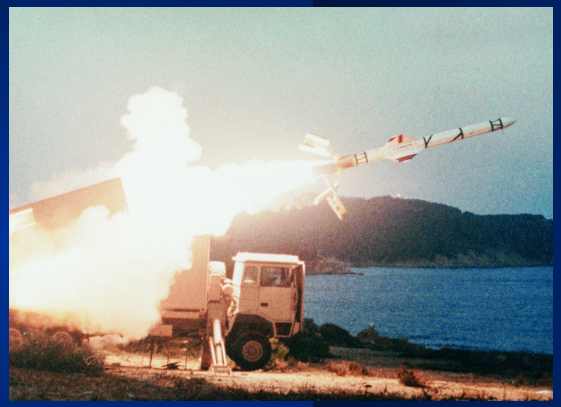
Associated Threat / Combat System	Multi-function Radar	Air Search Radar	Surface Search Radar	Mine Warfare Package	Variable Depth Sonar	Torpedo Early Warning
Aircraft						
UAV's						
SAM's						
ASCM						
USV's						
Small Boats						
Submarines						
UUVs						
Mines						

Weapons Systems Trade Off Scenarios

LCS self defense scenario

Threat	Scenario	Title	Description
M1 Low & Slow ASCM	1	Submarine Launched M1 ASCM	Two LCS undergoing ASW operations close to SeaBase
M1 Low & Slow ASCM	2	Four Surface/Air M1 ASCMs	LCS defending against airplanes attacking SeaBase
M1 Low & Slow ASCM	3	LCS Engaged by M1 Coastal batteries	Two LCS undertaking mine sweeping to clear a passage from SeaBase to shore. Positioned 8 miles from shore.
M2 Low & Fast ASCM	4	LCS Engaged by MIG-29 Carrying T2 ASCM	Two LCS are escorting an ExWar ship,

Simulation: LCS engaged by coastal batteries (ASCM)



Scenario	Sensor	Missile	Gun	Pra
S3	R1	D1	G1	0.927
S3	R1	D1	G2	0.965
S3	R1	D2	G1	0.936
S3	R1	D2	G2	0.942
S3	R2	D1	G1	0.952
S3	R2	D1	G2	0.942
S3	R2	D2	G1	0.942
S3	R2	D2	G2	0.959

S3: Scenario number 3

R1, R2: Sensor suites

D1, D2: Anti-missile Missiles

G1, G2: Guns

Pra: Probability of Raid Annihilation

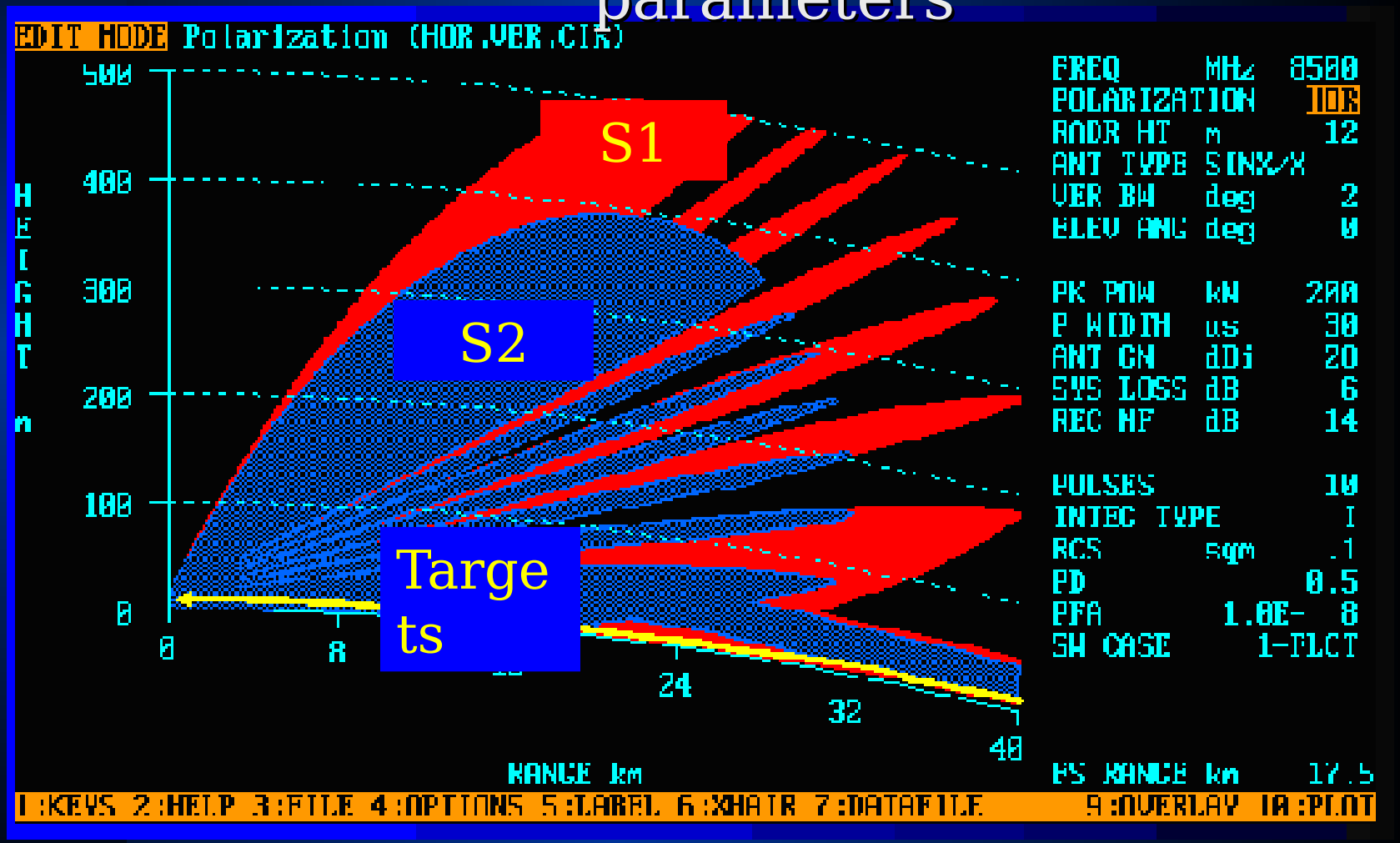
Weapons Systems Trade Off

Radar example: S2, S1 Radars

Concept	S2	S1
Coverage (2D/3D)	3D	3D
Frequency/Band	X Band	C or S
Antenna/Aperture Type	Active Phased	Passive
Probability of Sensor Availability (RM&A)	0.95	0.85
Size/Weight Estimate	20000	10000
*Transition to Track Time	1	4
*Minimum Range (needs to match weapon)	50	250
Electrical Power Rqmts	350	200
Signature (RCS/IR) contribution	1	2
Systems quantity	1	3
Complexity	3	1

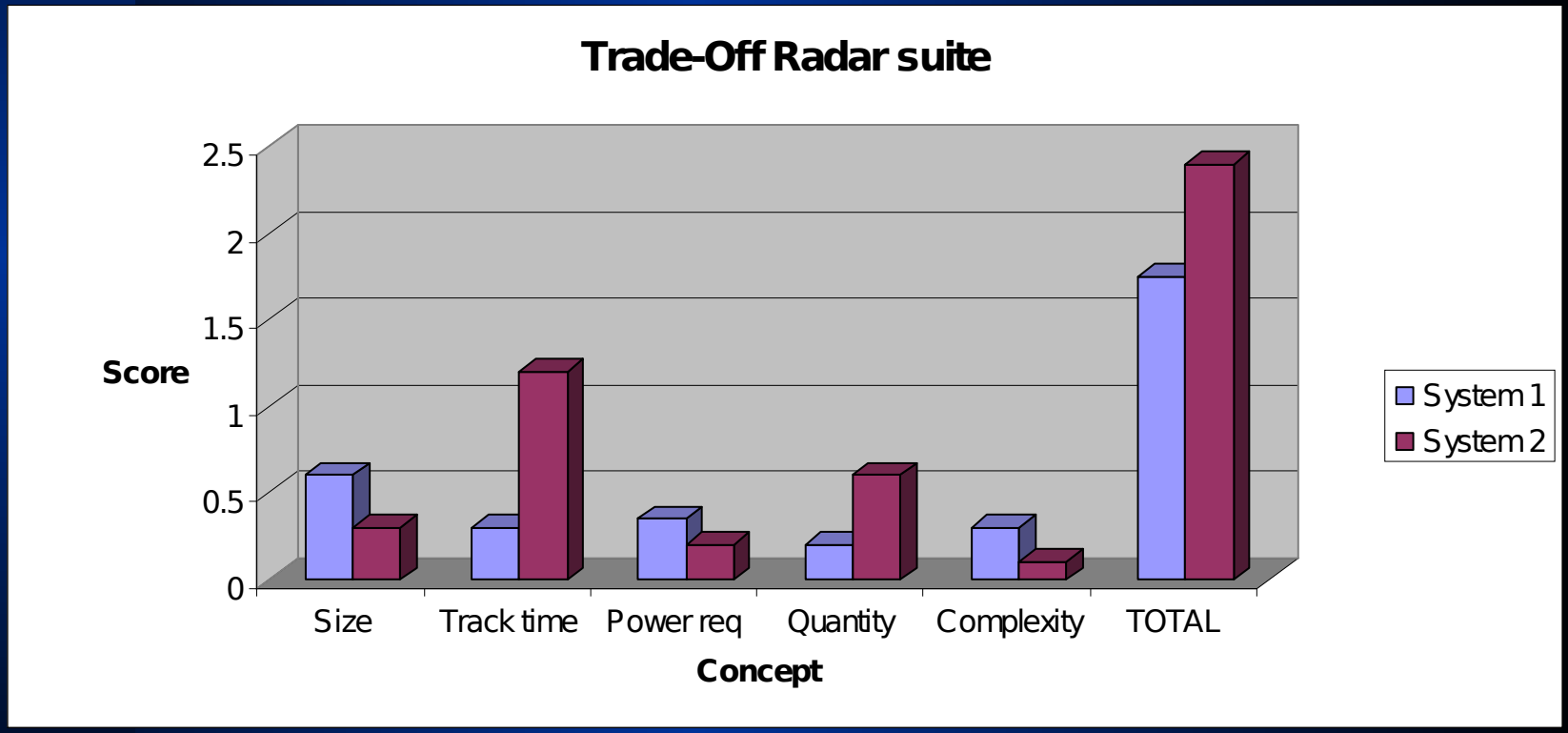
Weapons Systems Trade Off

Radar example: non relevant parameters



Weapons Systems Trade Off

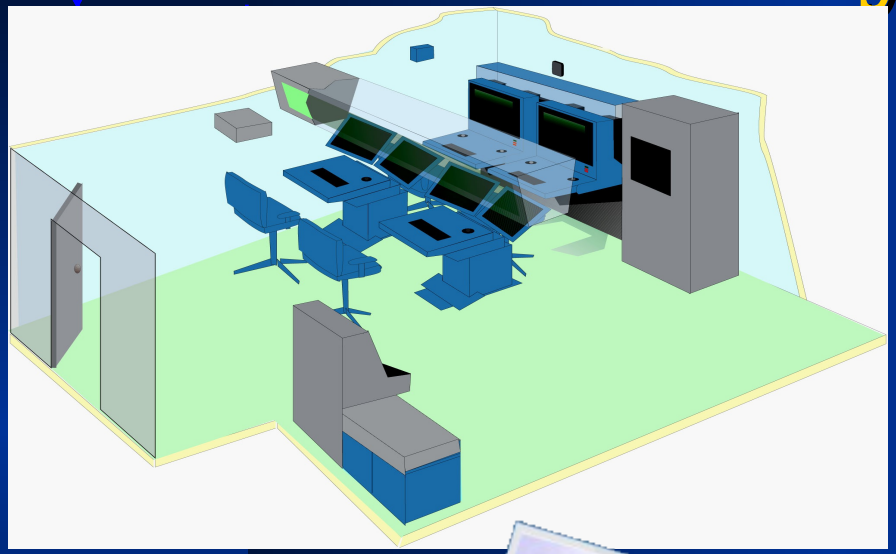
Radar example: relevant parameters



Mission packages

1. **Ship's payload limit: 160 LT (app)**
2. **Core package (CP)**
   - Basic package (BP). Ship standard plus self defense.
   - Surface Warfare package (SUWP)
3. **Anti Air Warfare package (AAWP)**
4. **Anti Submarine/ Mine Warfare package(ASW/MIWP)**
5. **Weapons systems Weight Limit:**
   - CP + AAWP ≤ 160 LT

Core Mission Package Systems



Basic Package

- Multi-Function Radar (APAR)
- Command and Control System
- EW Suite
- Navigation Radar
- EO/IR/UV/LLTV Suite
- Communications Suite
- Hull Mounted Sonar
- Real Time Degaussing System

Core Package Systems (cont)

Basic Package

- Sea Ram
- Helicopter and UAV capable
- Signature management system
- Nixie
- Torpedo warning receiver
- High precision

Core Package Systems (cont)

SUW Package

- Harpoon Missiles (x4)
- Mk III 57 mm BOFORS gun
- Rigid Hull Inflatable Boats (RHIB) (x2)

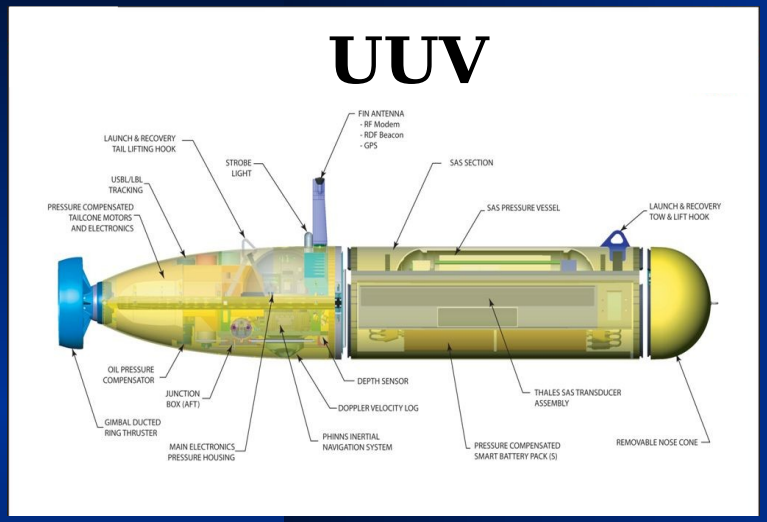
USW/MIW Mission Package

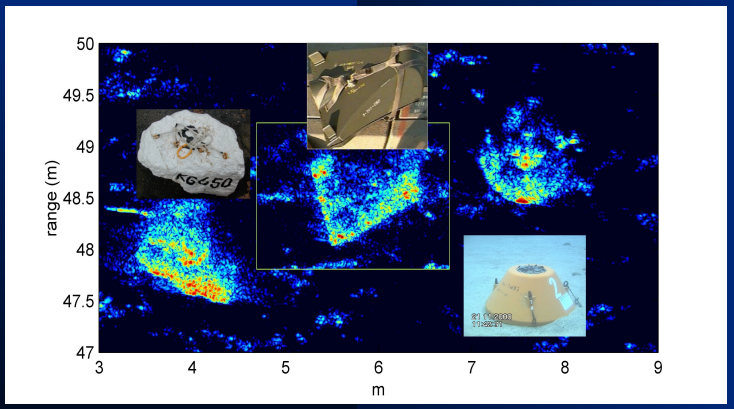
USW

- Mk 32 Mod 15 Torpedo Launcher
- Mk 50 Torpedoes (x 6)
- Low Freq Active Towed Sonar. (LFATS)
- LAMPS (aircraft sonar, sonobuoy and torpedo capable)

USW/MIW Mission Package

UUV





MIW

- Advanced Side Looking Sonar (ASLS)
- Mine-Hunting UUVs
- Expendable Mine Destructor (EMD)
- Airborne Laser Mine Detector System (ALMDS)
- Rapid Airborne Mine Clearance System (RAMICS)
- Organic Airborne & Surface Influence Suite (OASIS)
- Airborne Mine Neutralization System (AMNS)

AAW Mission Package

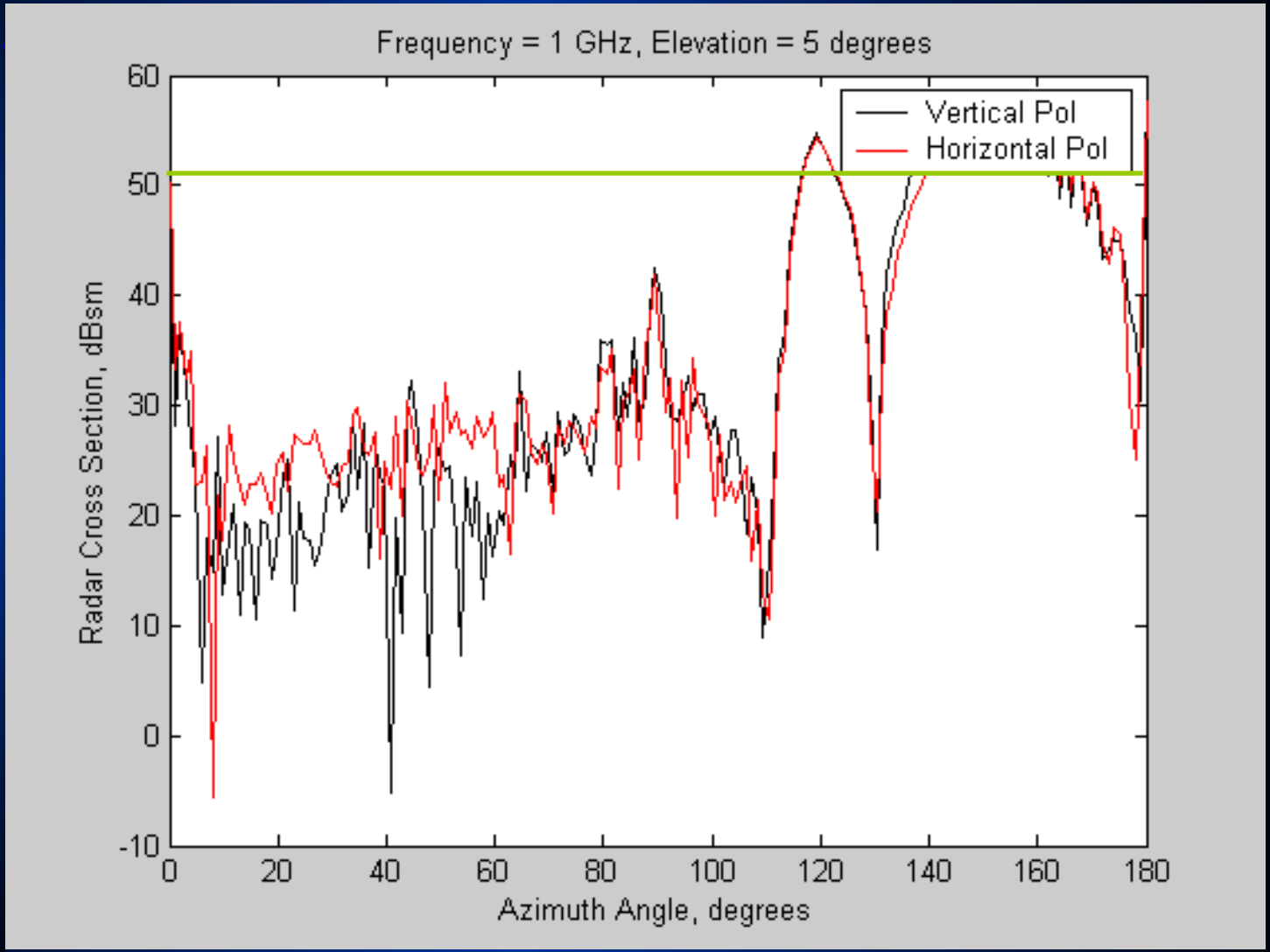
AAW

- Mk 41 8-cell Vertical Launching System
- Evolved Sea Sparrow Missile (x 32 using Mk 25 Quad-Pack)

Signatures

RCS

Freq: 1 GHz
Elev: 5 deg



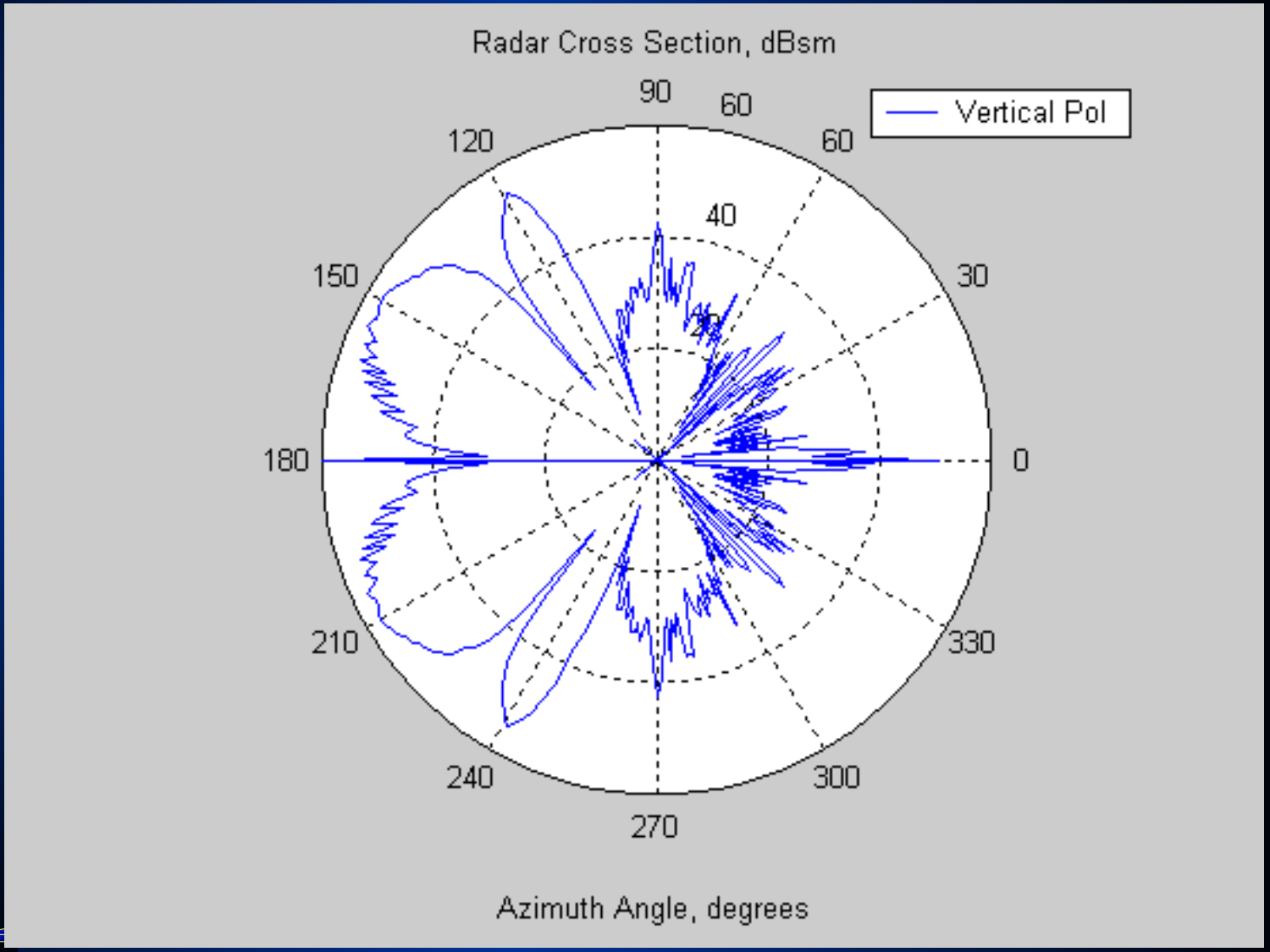
Signatures (cont)

RCS

Freq: 1 GHz

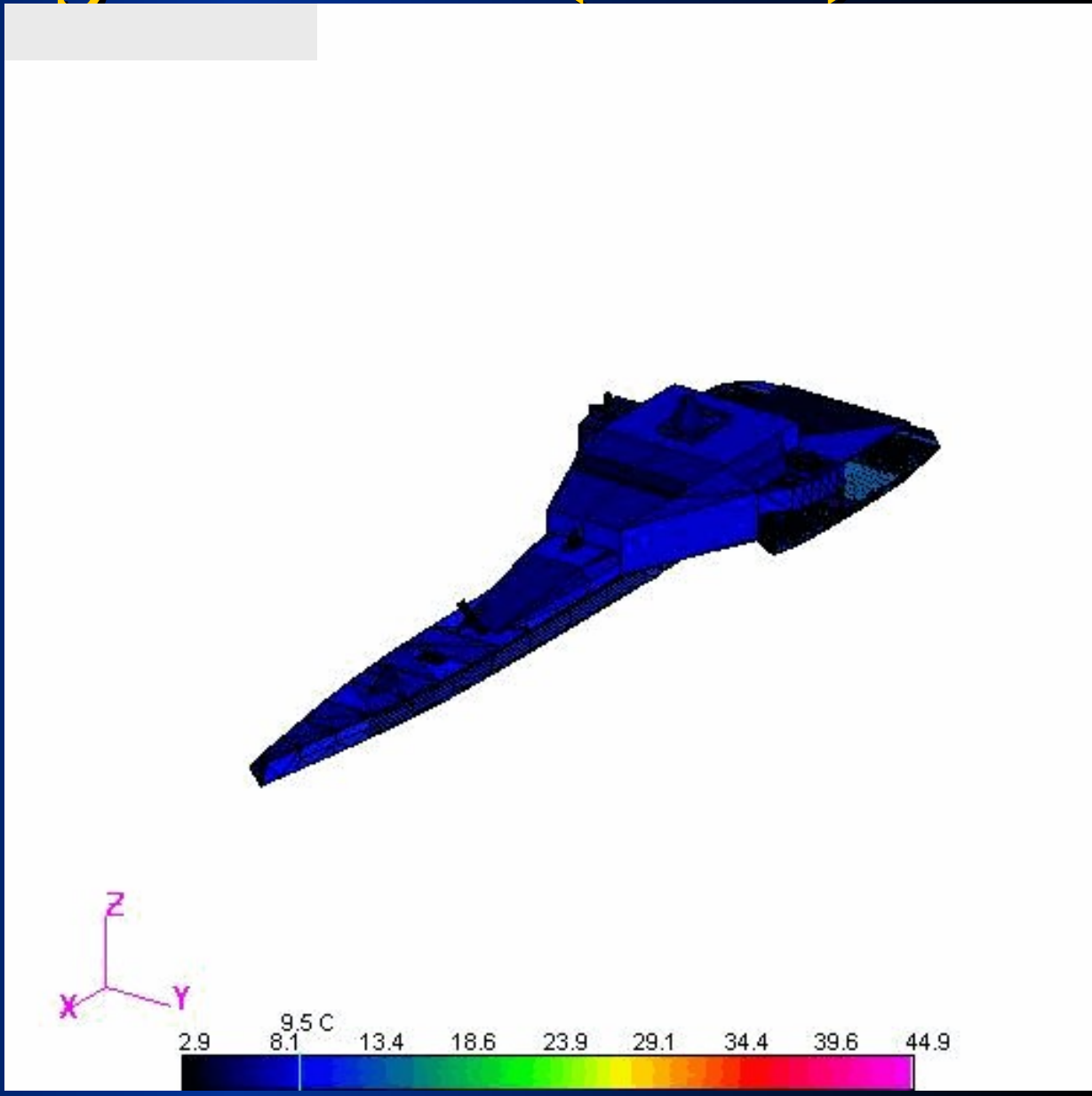
Elev: 5 deg

Polar graph



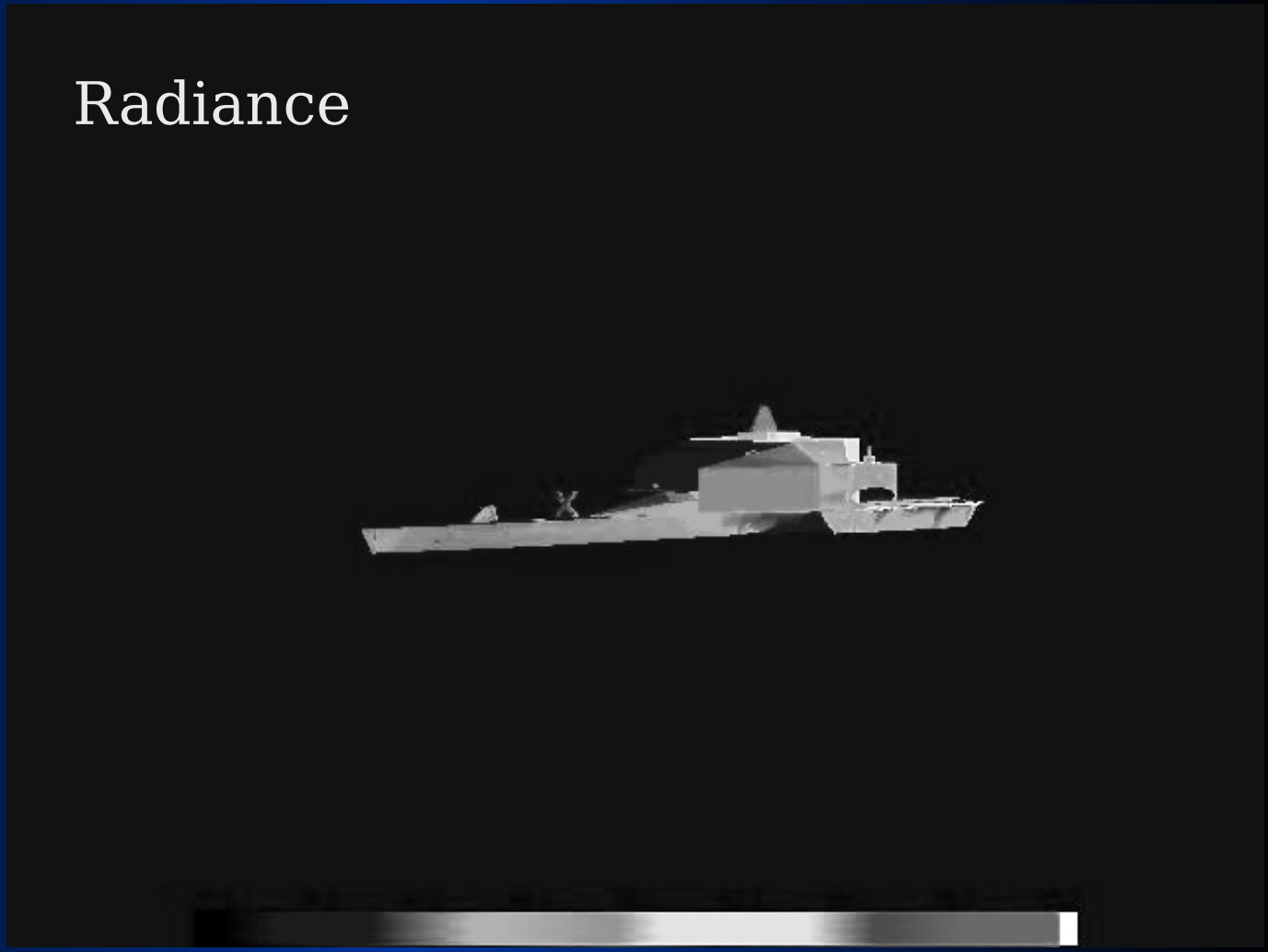
Signatures (cont)

Temperature Prediction (Environmental)



Signatures (cont)

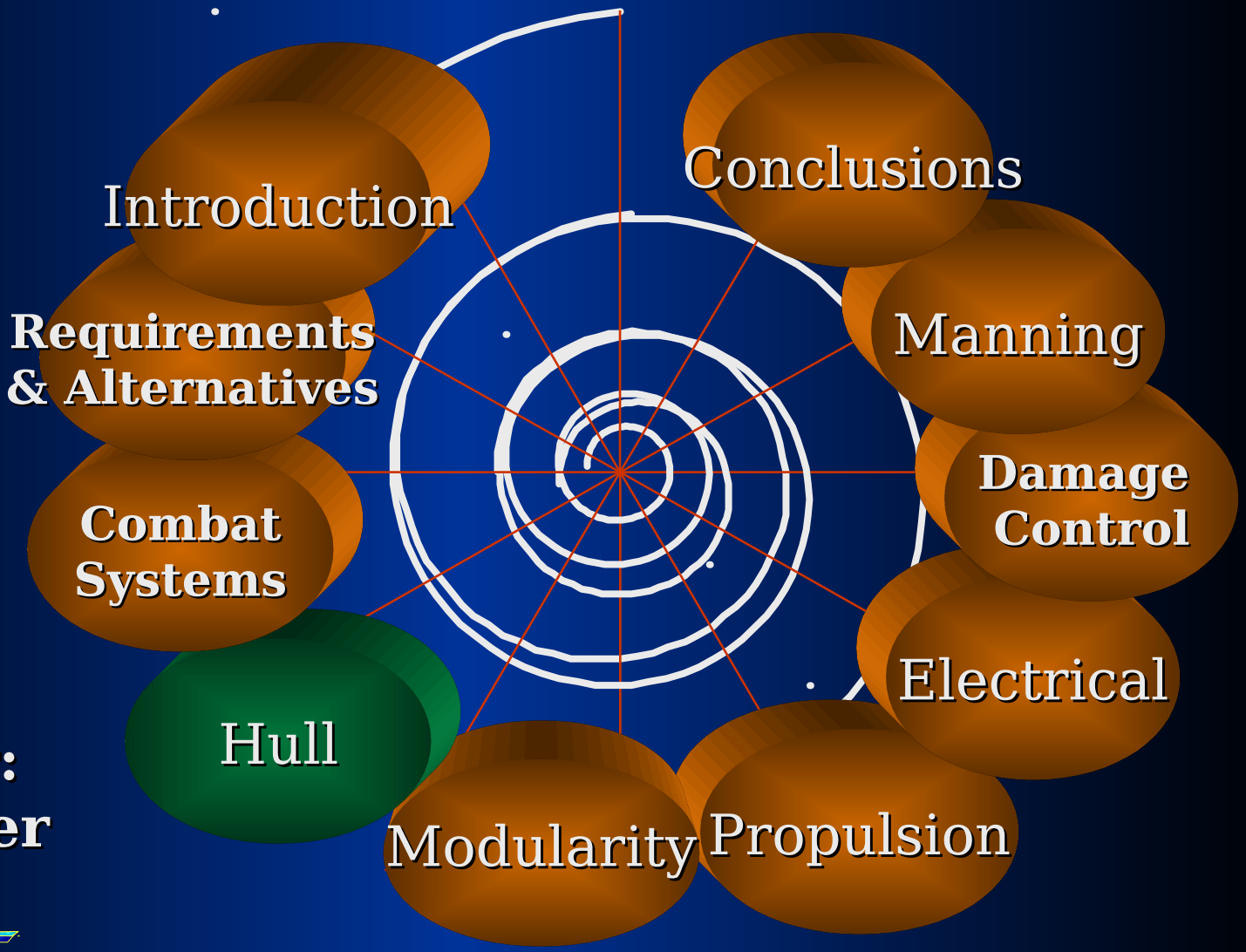
IR Signature (10 Km, staring sensor)



Summary

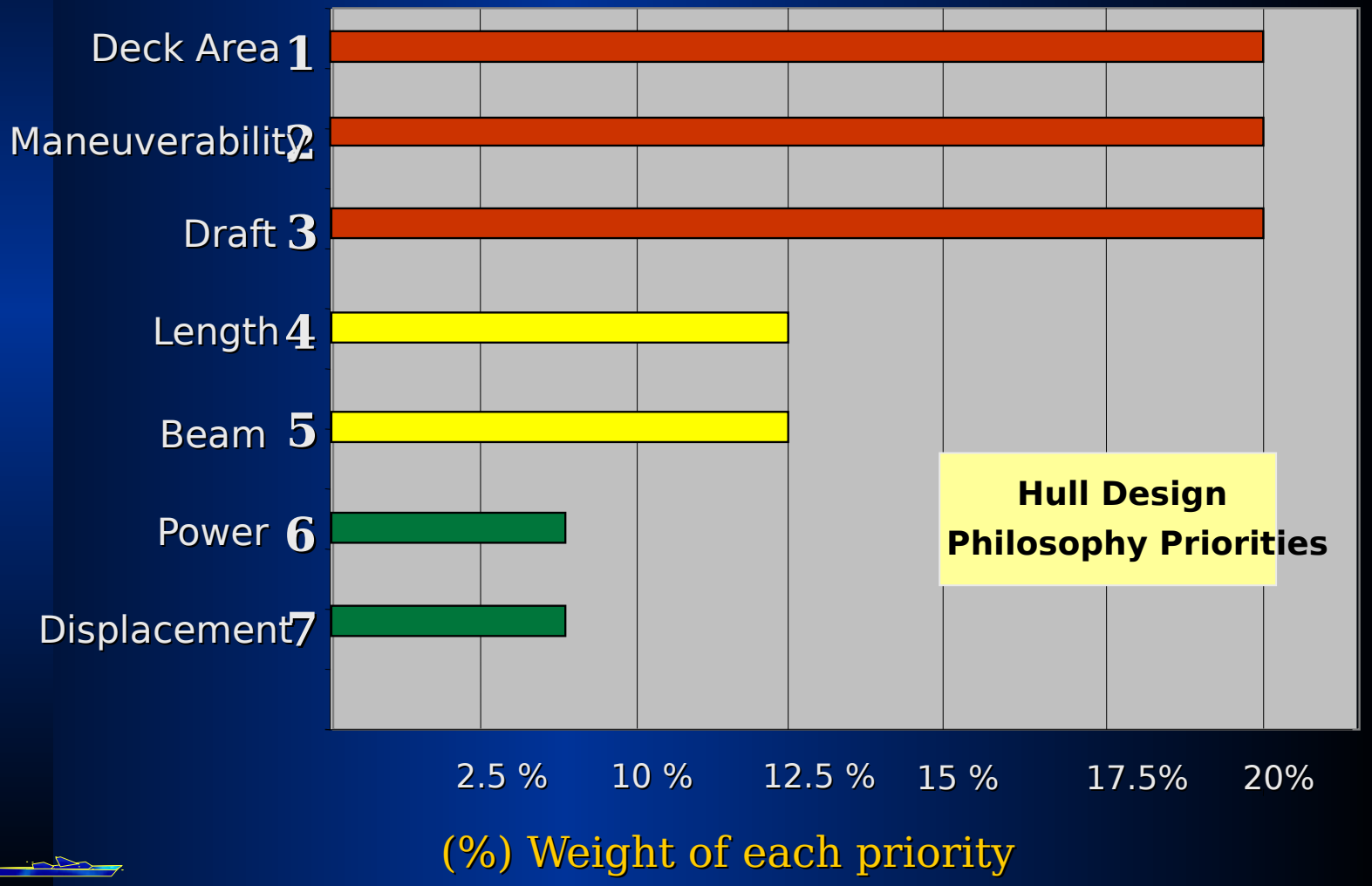
- Threats
- Scenarios
- Trade off
- Mission Packages
- Signatures

Hull Design



Next Speaker: LTJG Zafer Elcin

Initial Hull Design Philosophy



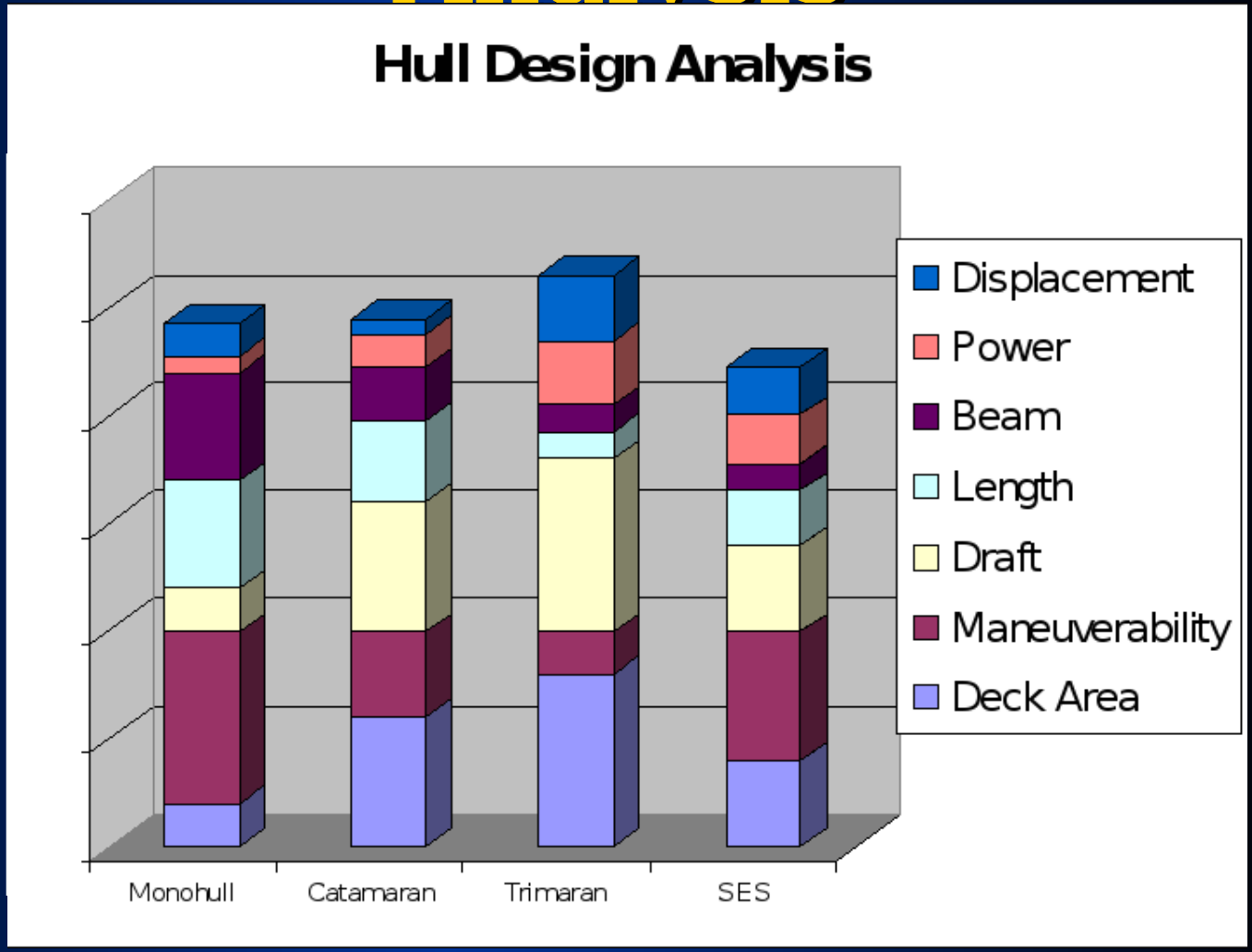
Hull Form Candidates

Initial Hull Design Analysis

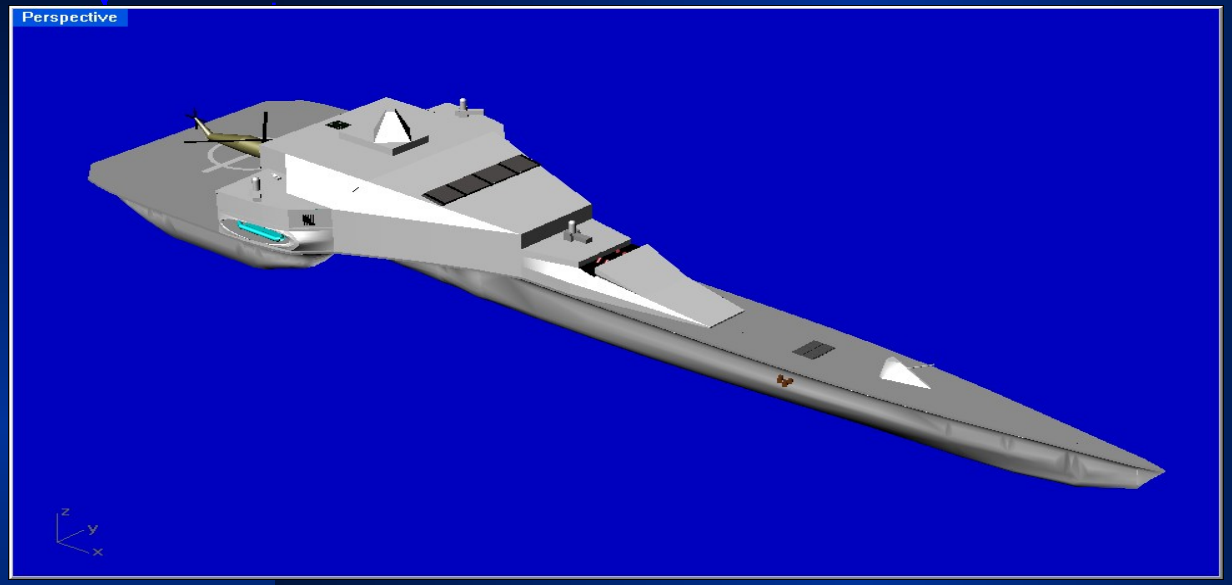
Priority	Monohull	Catamaran	Trimaran	SES
Deck Area	0.2	0.6	**0.8**	0.4
Maneuverability	0.8	0.4	**0.2**	0.6
Draft	0.2	0.6	**0.8**	0.4
Length	0.5	0.375	**0.125**	0.25
Beam	0.5	0.25	**0.125**	0.125
Power	0.075	0.15	**0.3**	0.225
Displacement	0.15	0.075	**0.3**	0.225
Total	2.425	2.45	**2.65**	2.25

***Sum of the product of each priority weight and ranking**

Initial Hull Design Analysis



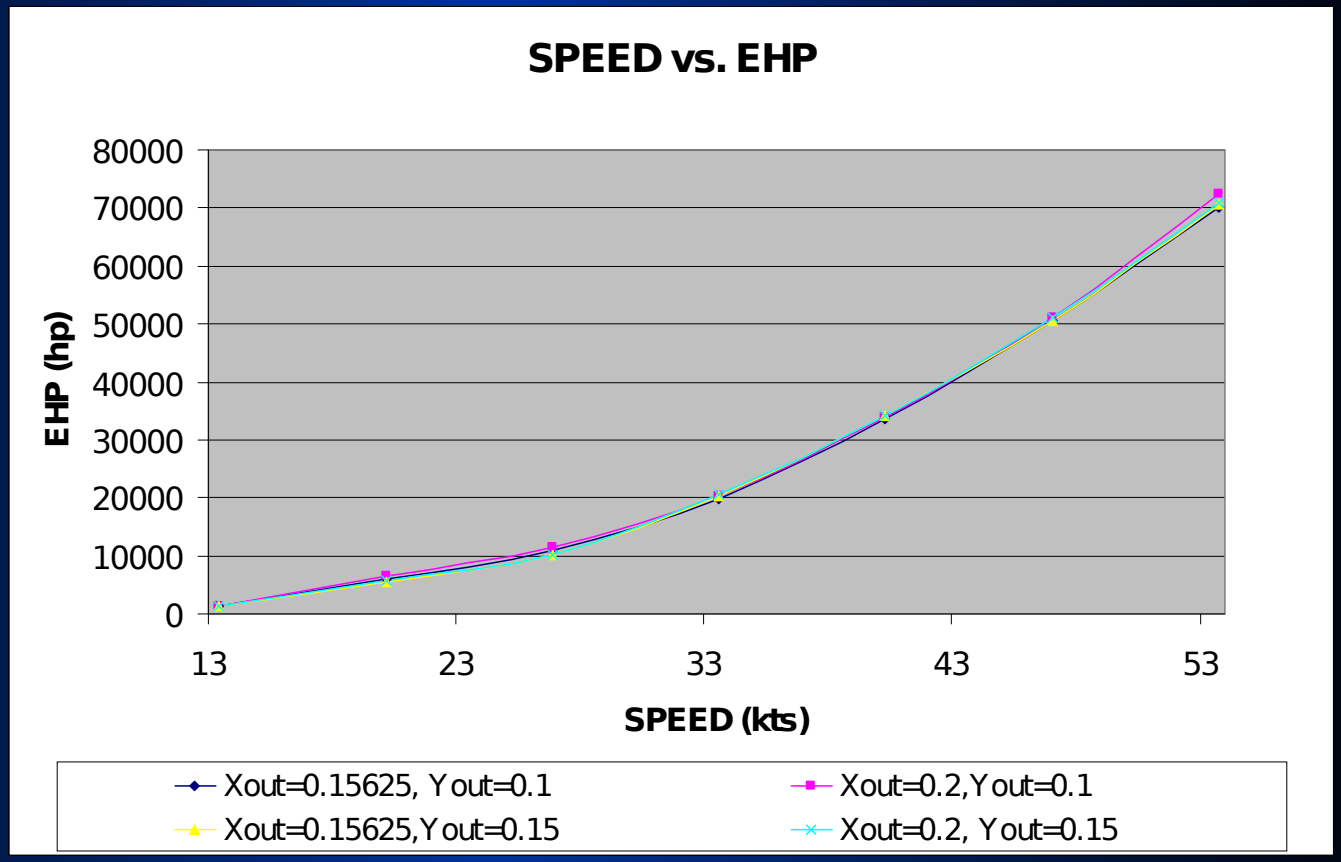
Hull Design Processes



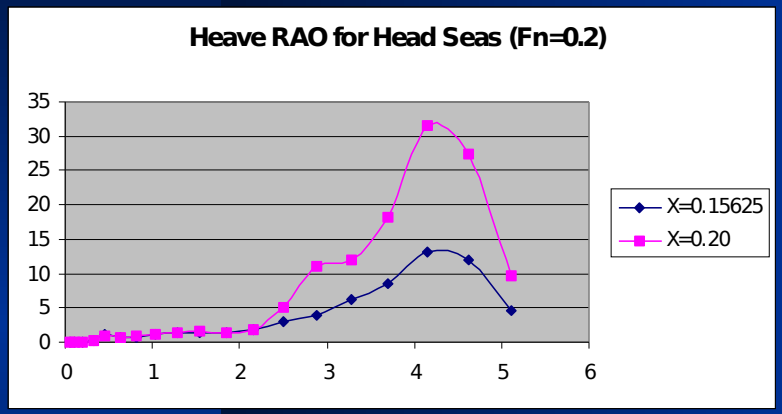
Advantages

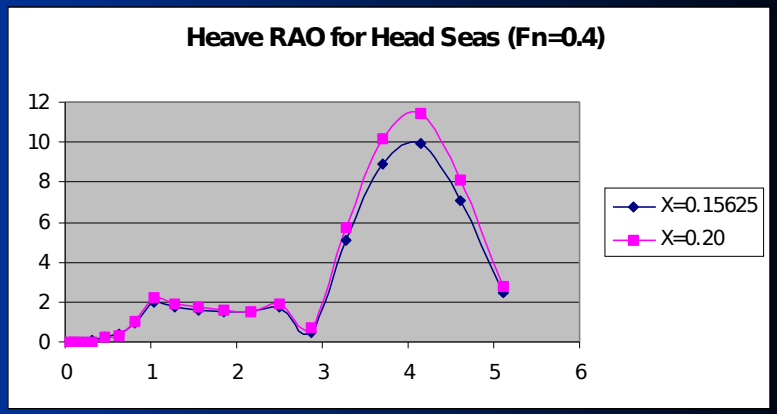
- Resistance
- Seakeeping and Motions
- Maneuverability
- General Arrangement
- Survivability
- Signature Reduction

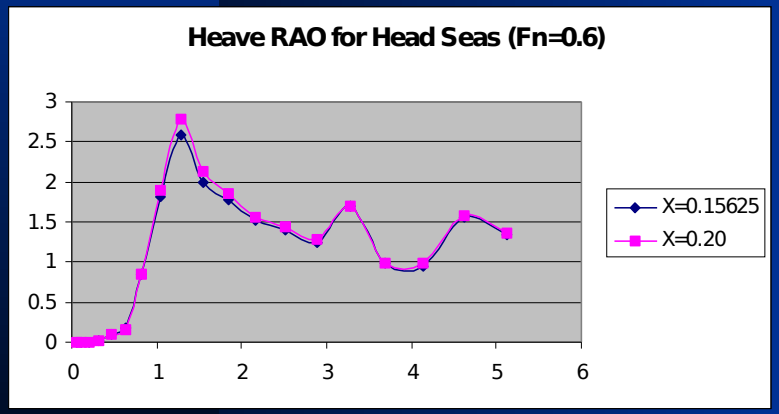
Side Hull Positioning – Resistance and Powering

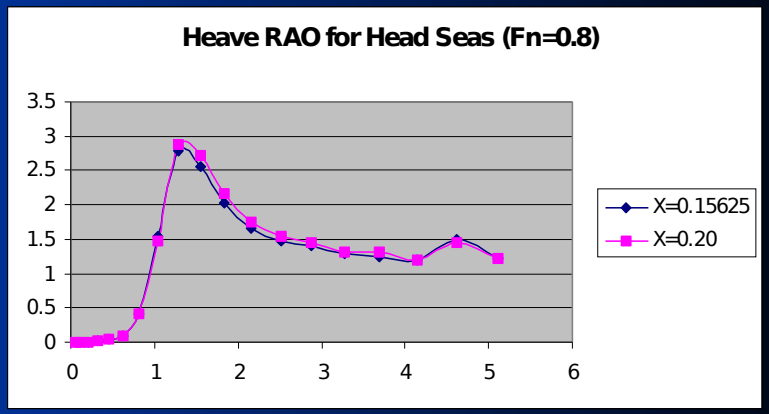


Side Hull Positioning – Seakeeping

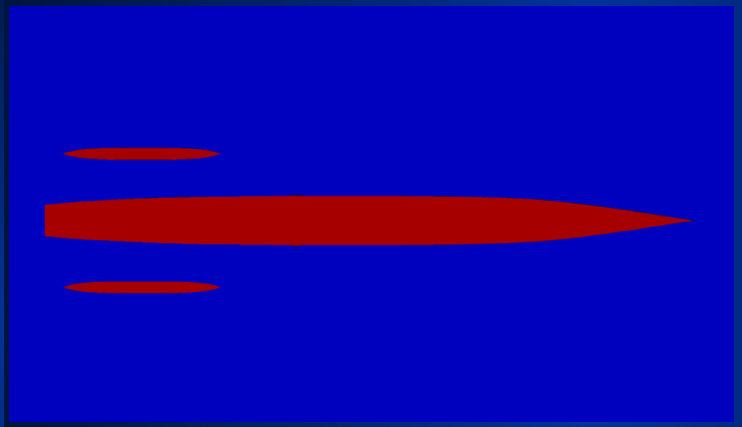


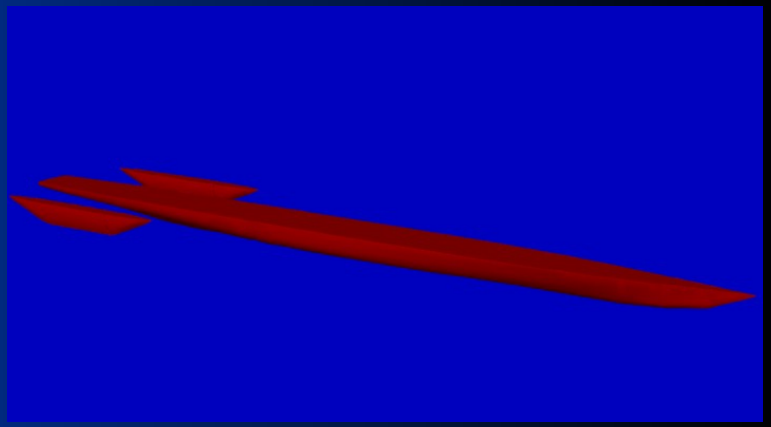


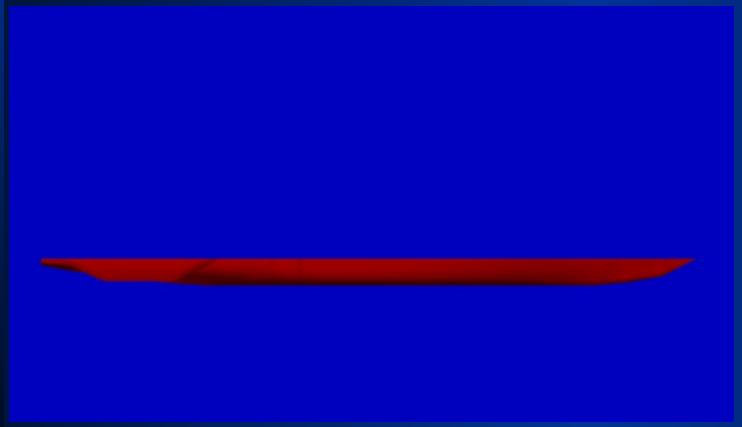


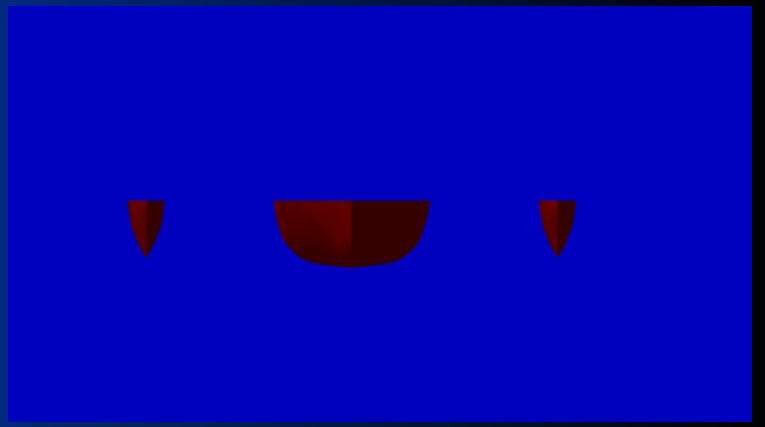


Side Hull Positioning

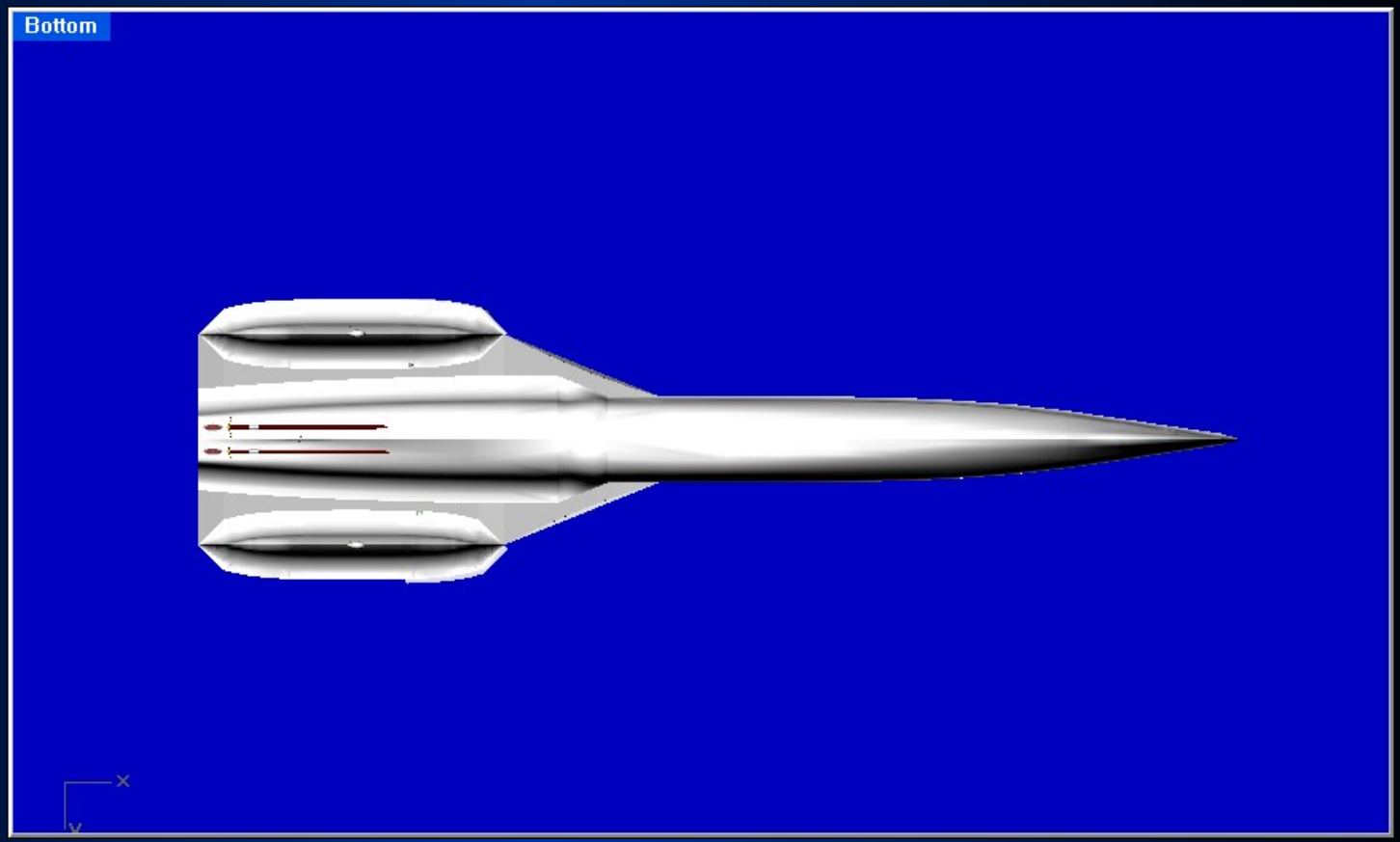








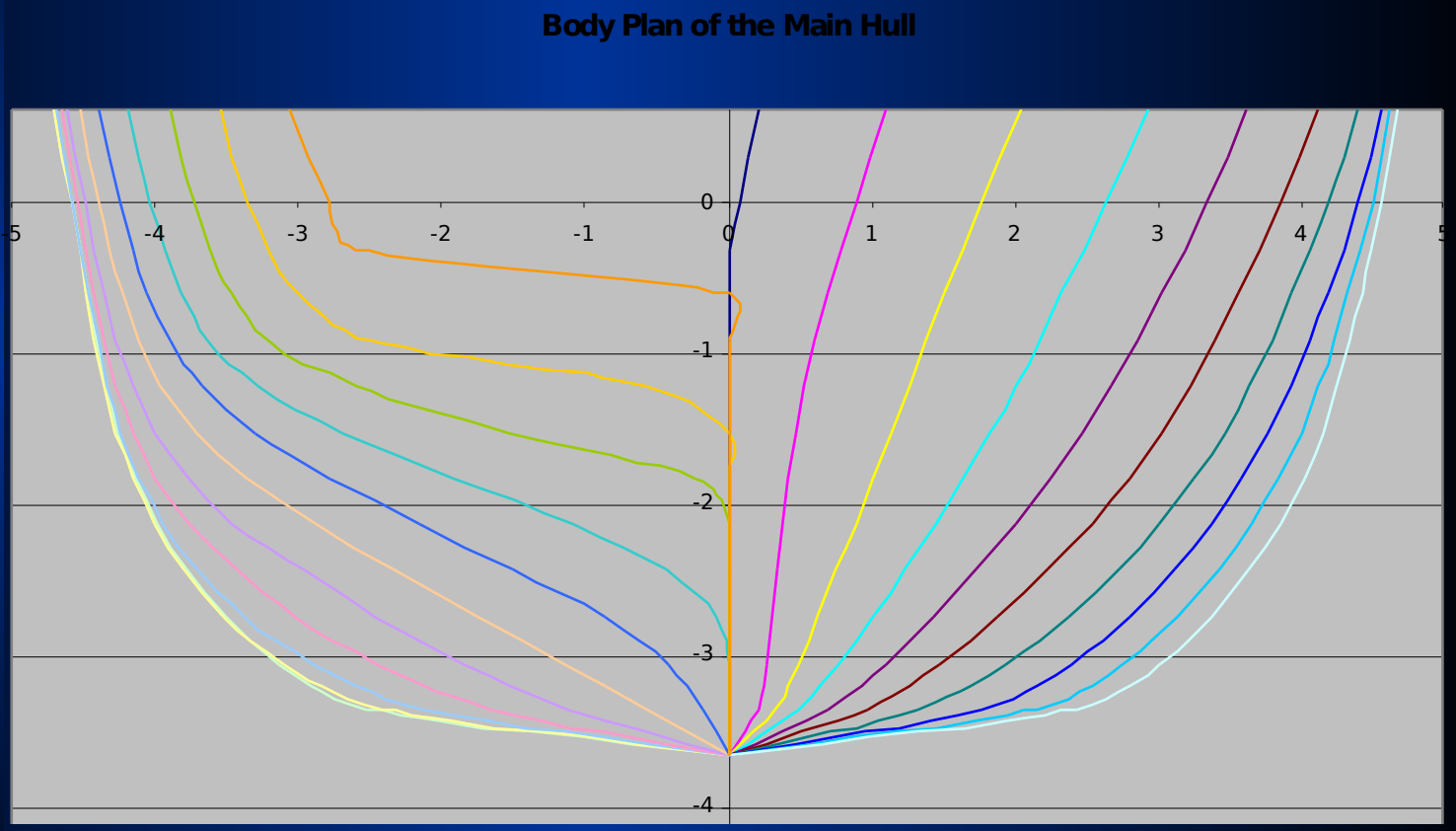
Side Hull Positioning



Characteristics of SEA SWAT

Characteristic	Main Hull	Side Hull
Length (L_{BP})	400 ft	125 ft
Beam (B)	30.8 ft	7.5 ft
Total Beam for $Y_{out} / L_{pp} = 0.1$	89.5 ft	
Draft (T)	12 ft	10 ft
L/B	13.0	16.7
$L/\tilde{N}^{1/3}$	9.39	7.54
Block Coefficient (C_B)	0.53	0.50
Midship Coefficient (C_M)	0.84	0.68
Waterplane Coefficient (C_W)	0.81	0.79
Volume	77226 ft^3	4558ft^3
Displacement	2206 LT	130 LT
Total Volume	86343 ft^3	
Total Displacement	2466 LT	

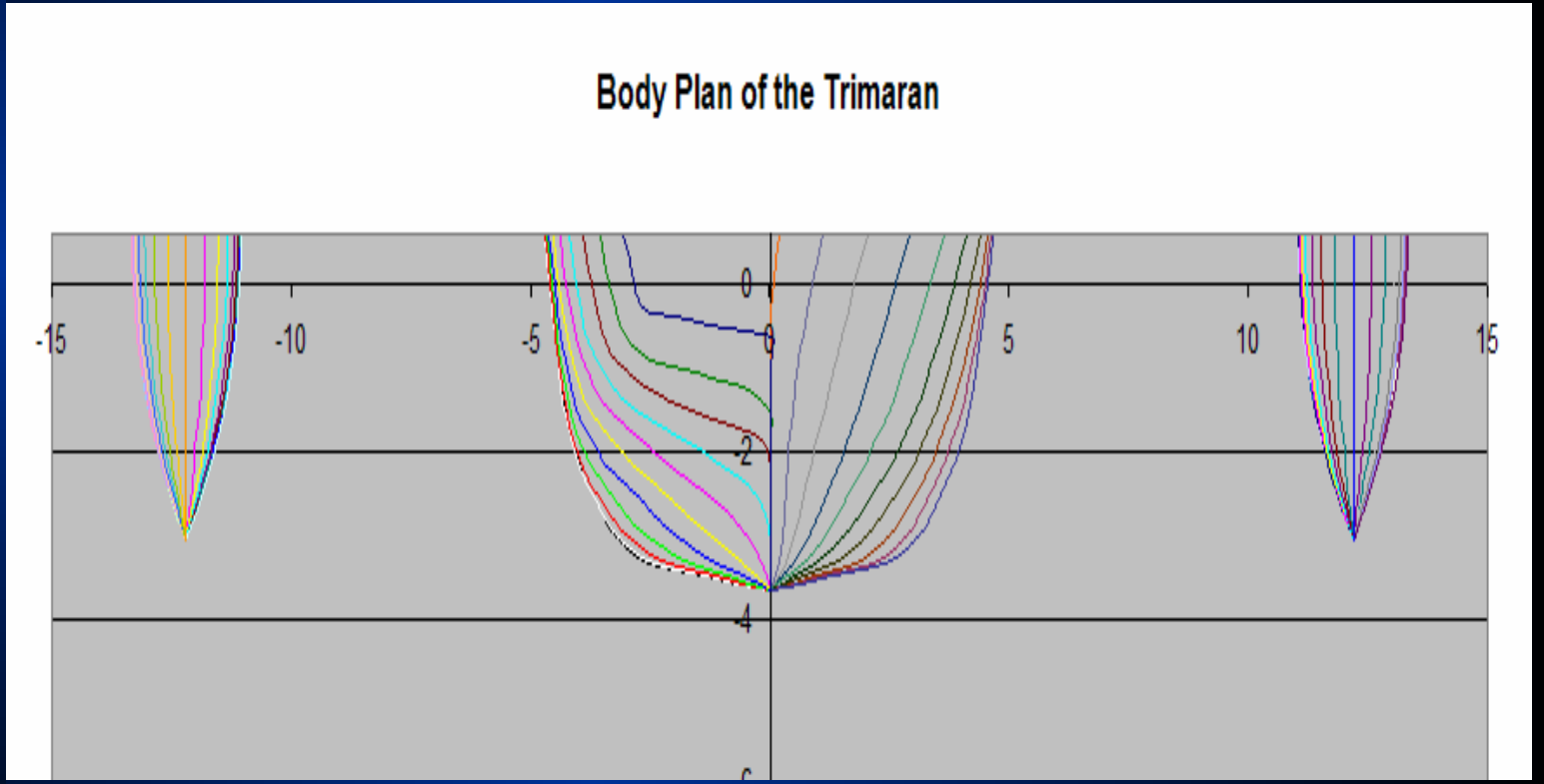
Body Plan of SEA SWAT Main Hull



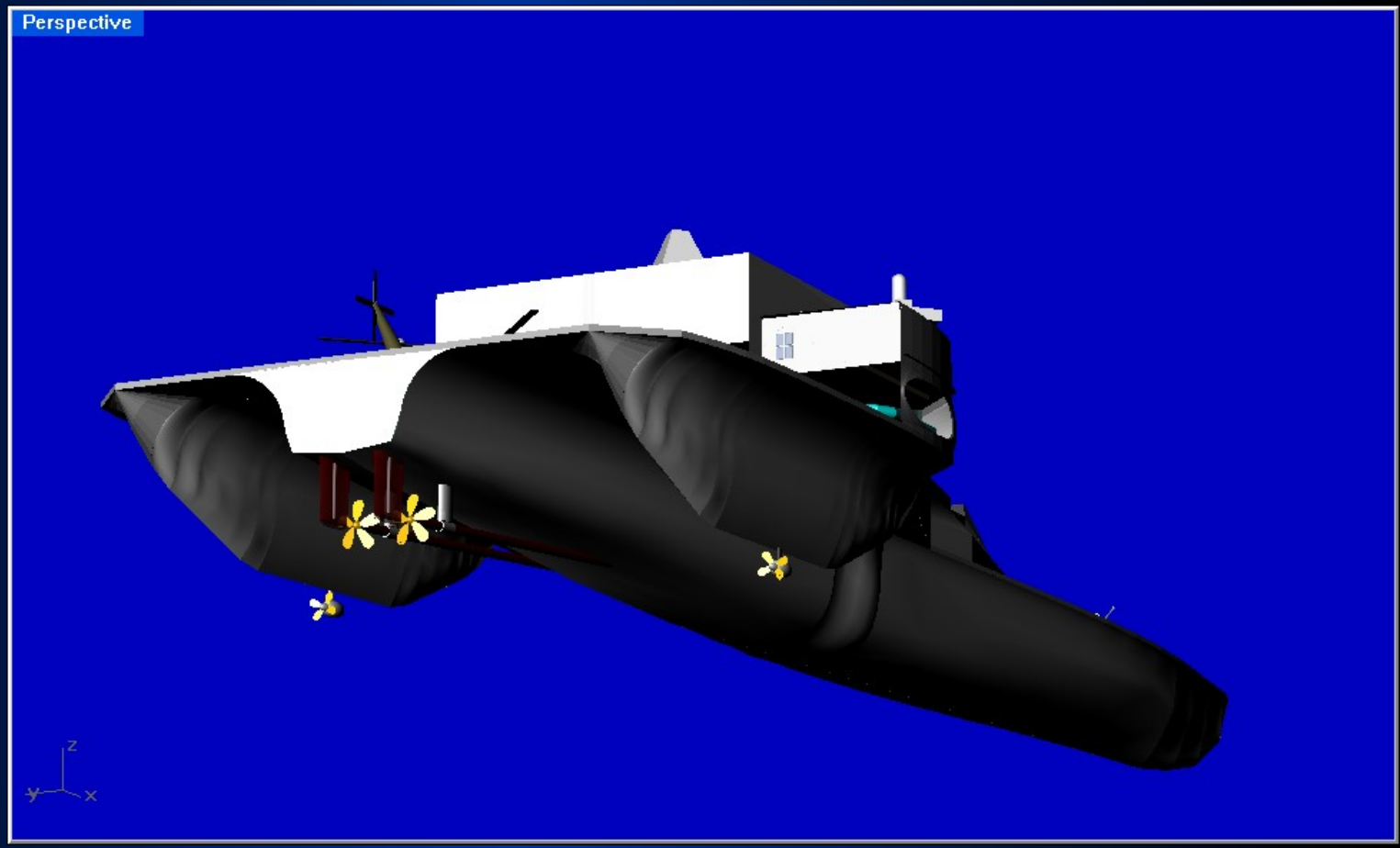
Body Plan of SEA SWAT Side Hull

Total Ship Systems Engineering

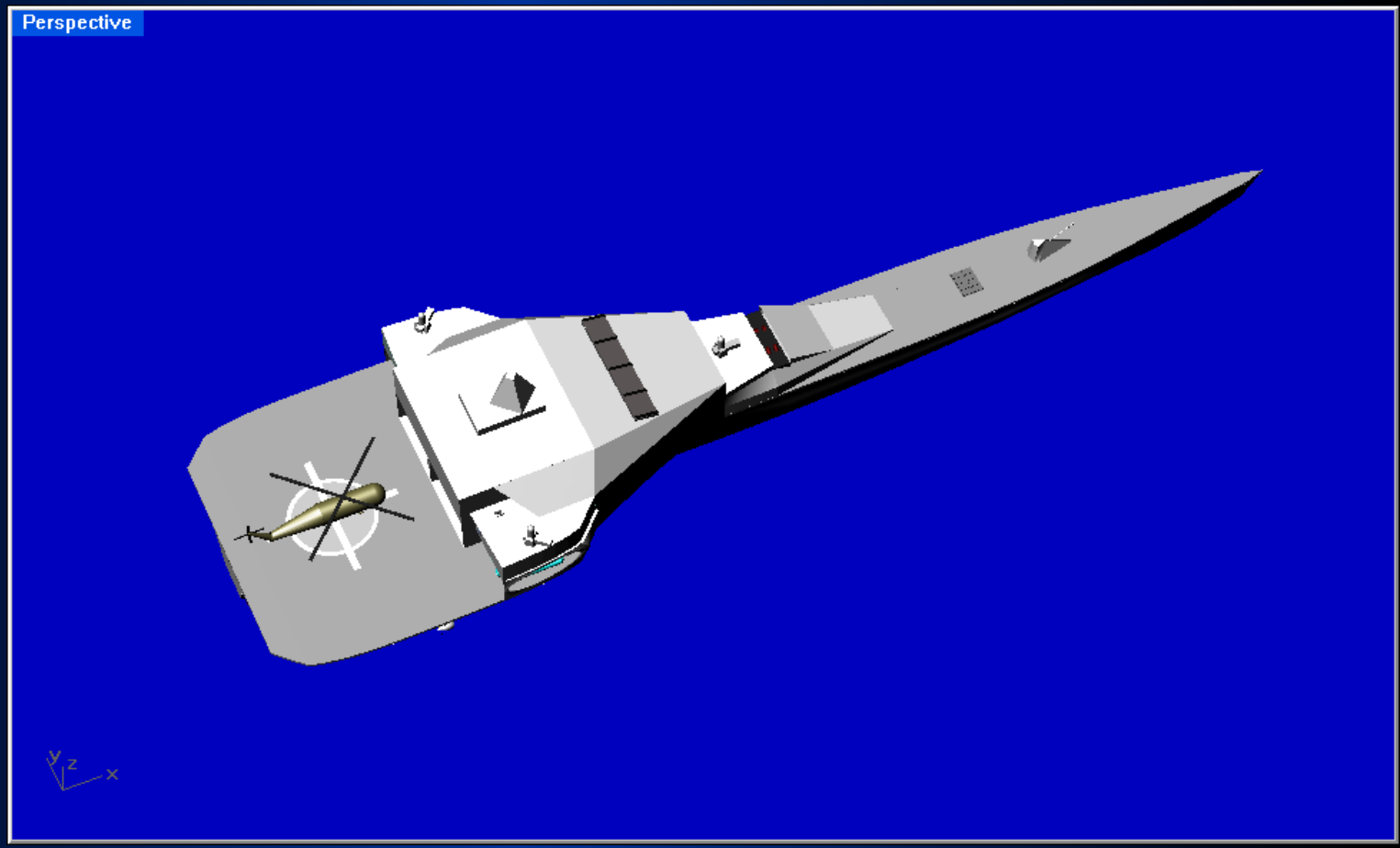
Body Plan of SEA SWAT



Maneuverability

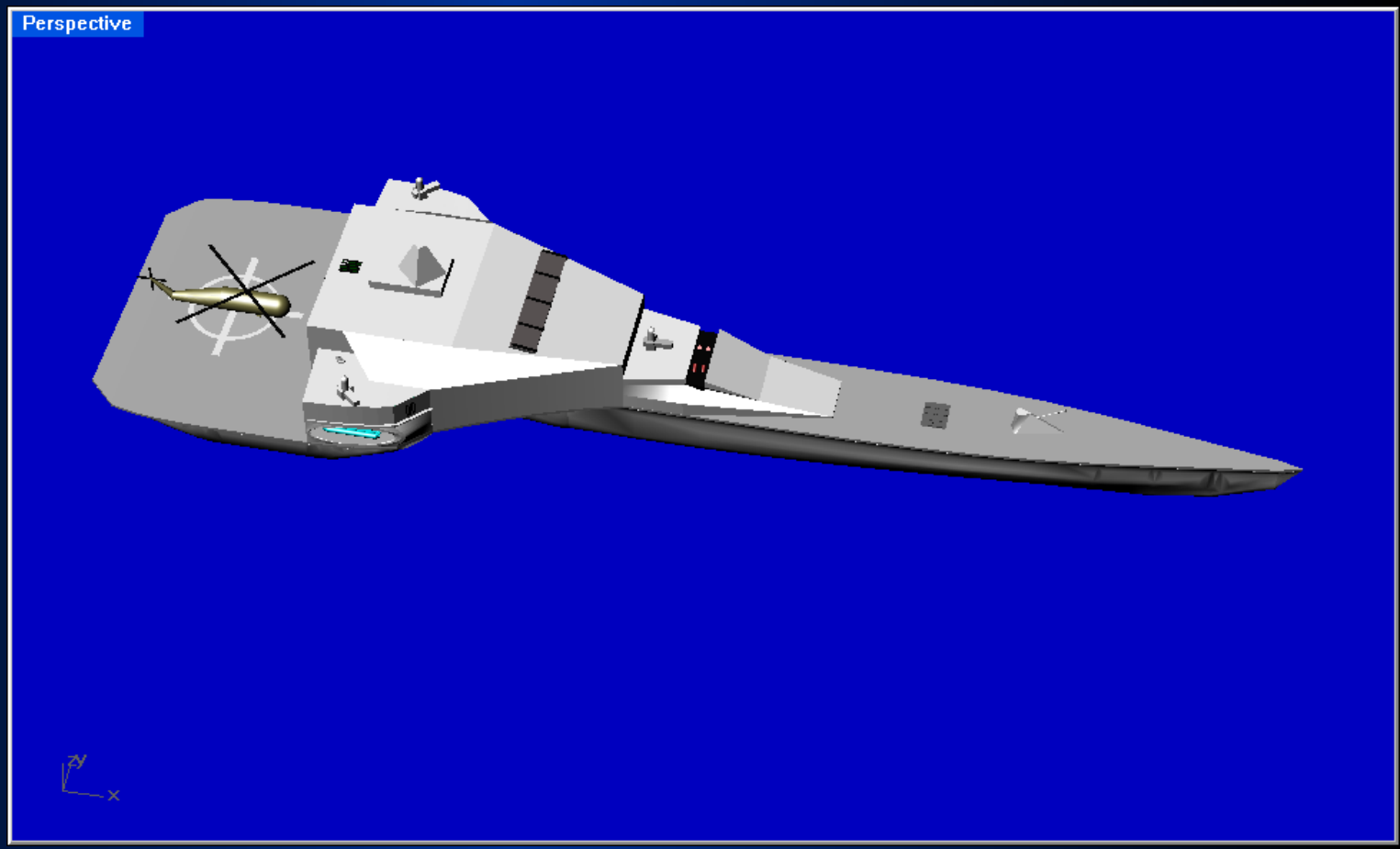


General Arrangement



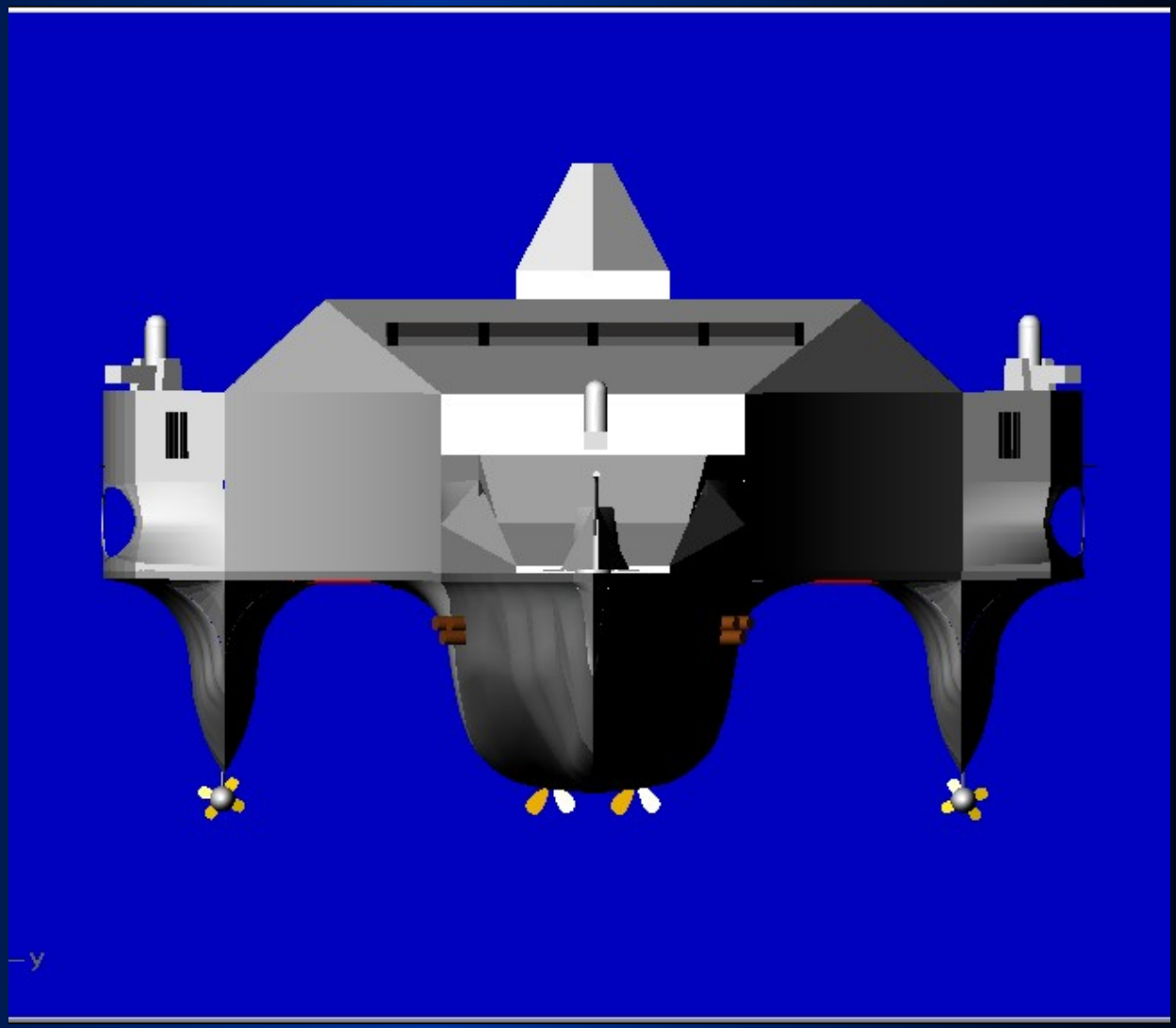
SEA SWAT

General Arrangement

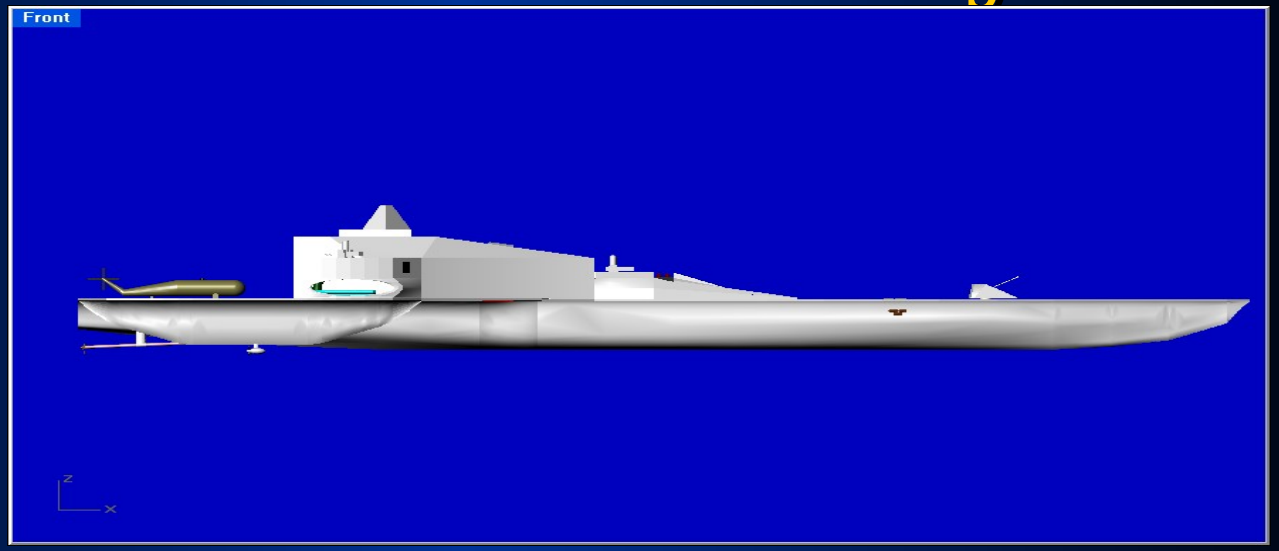


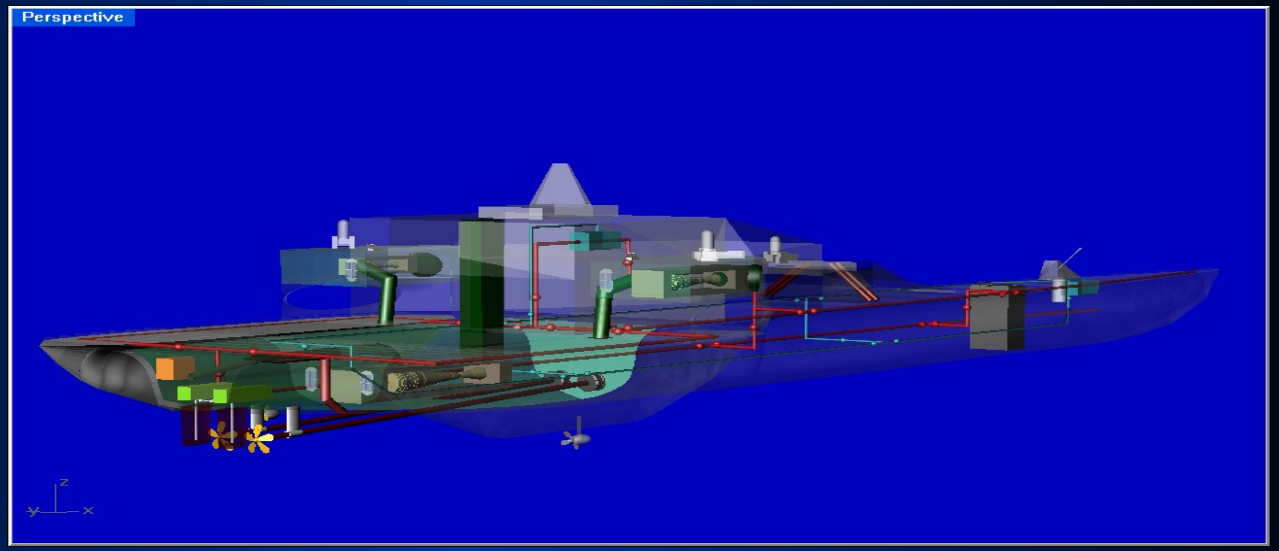
TSSE Total Ship Systems Engineering

General Arrangement

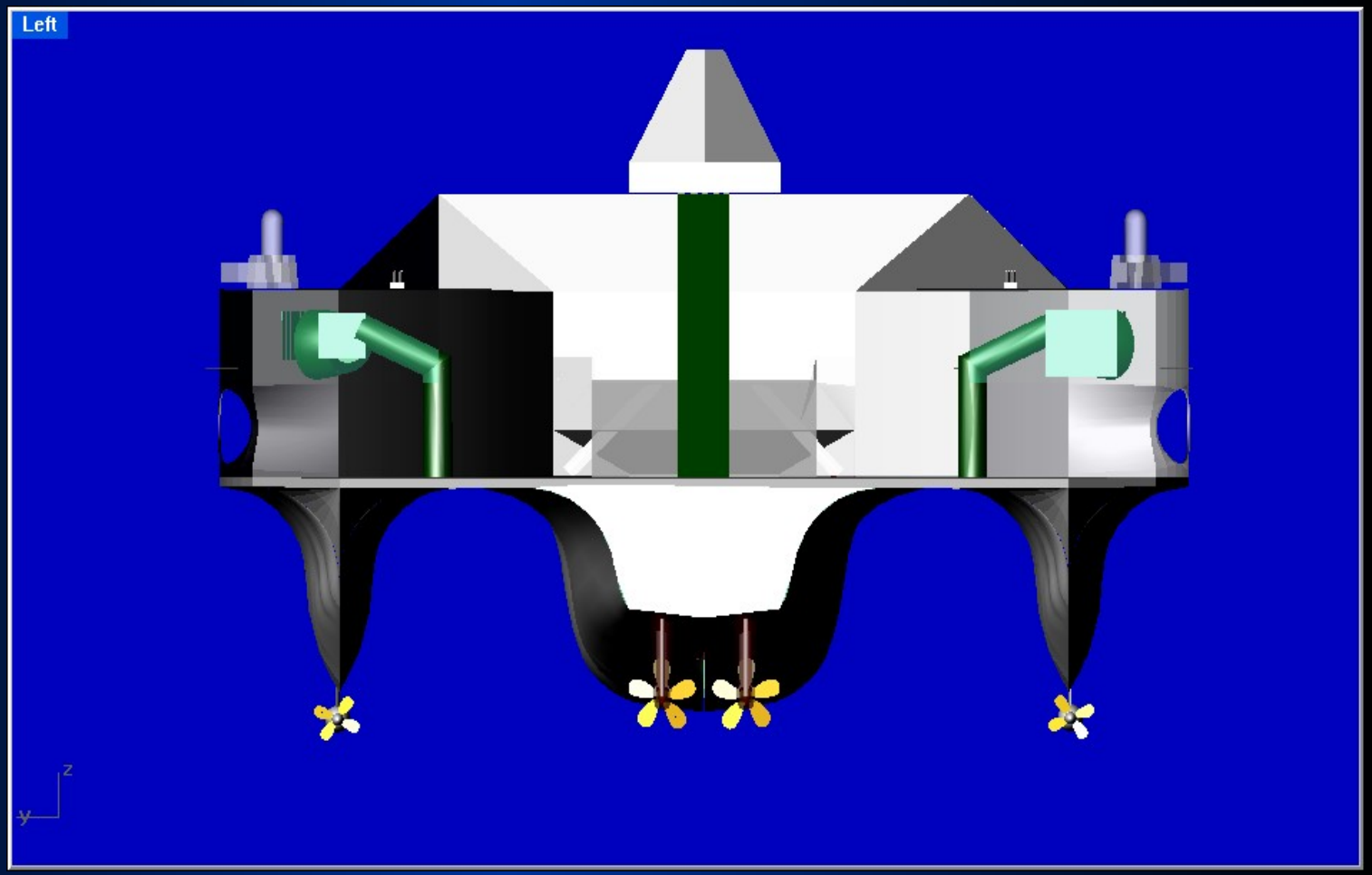


Survivability

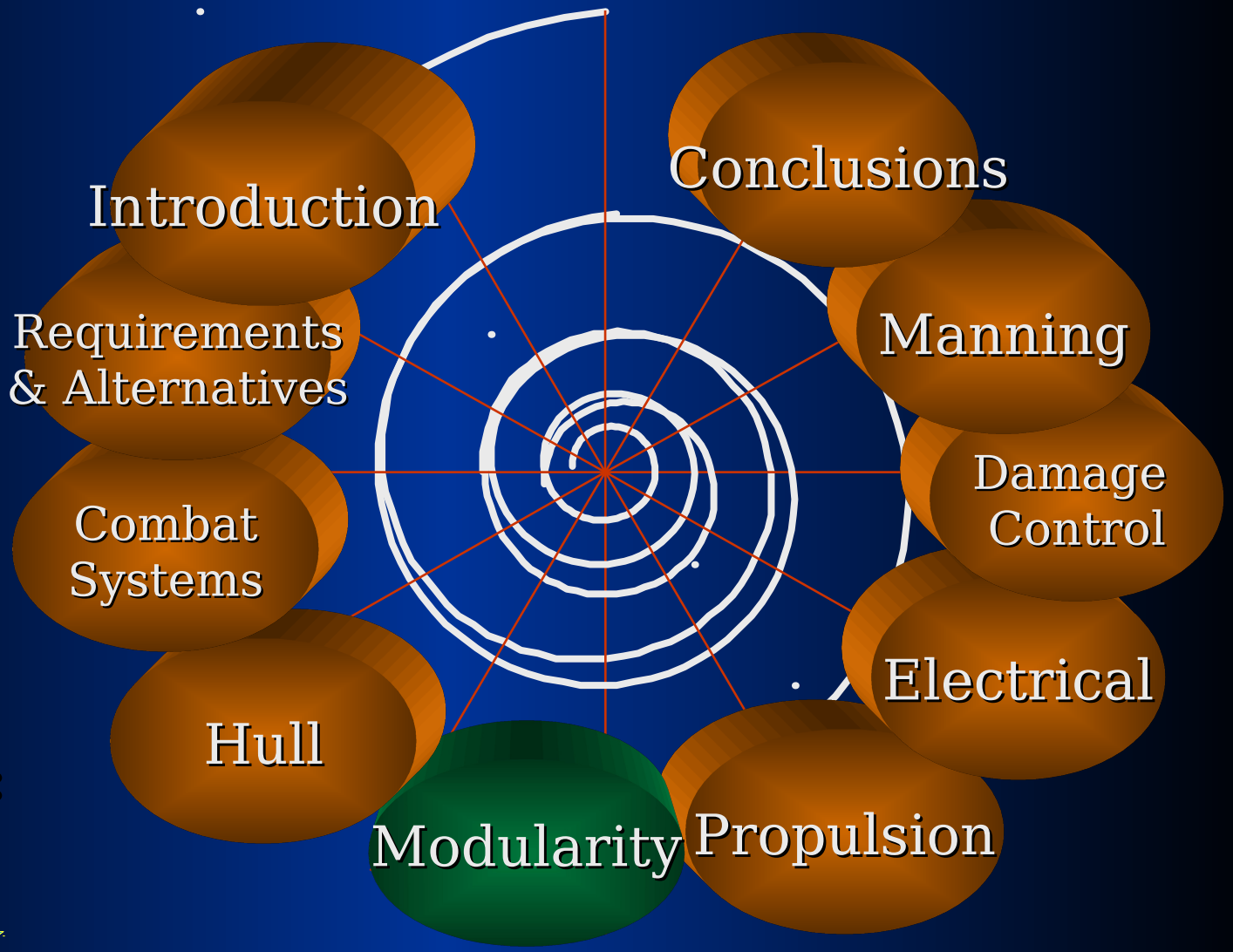




Signature Reduction



Modularity Design



Next Speaker: LT Scott Lunt

Modularity

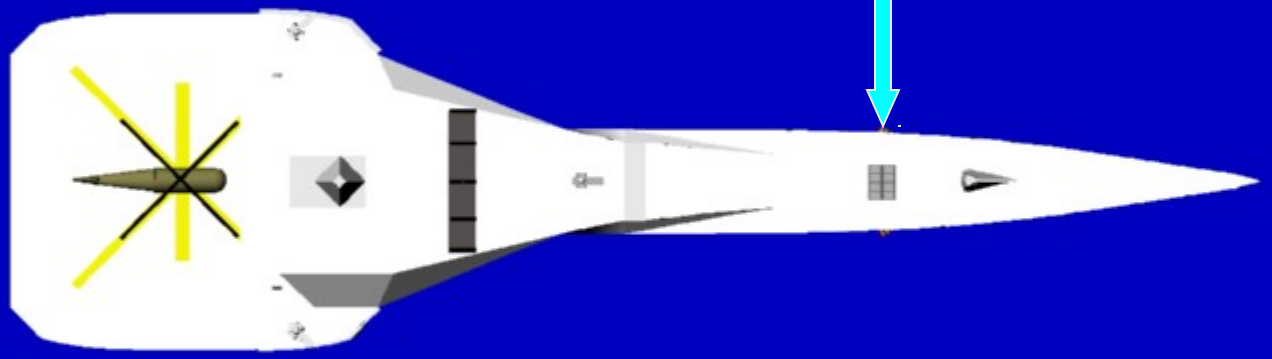
- Definition
- Application to SEA SWAT

Modularity

- Mission Packages
  - AW
  - USW/MIW
- Core Systems

Modularity

VLS/Torpedo Handling



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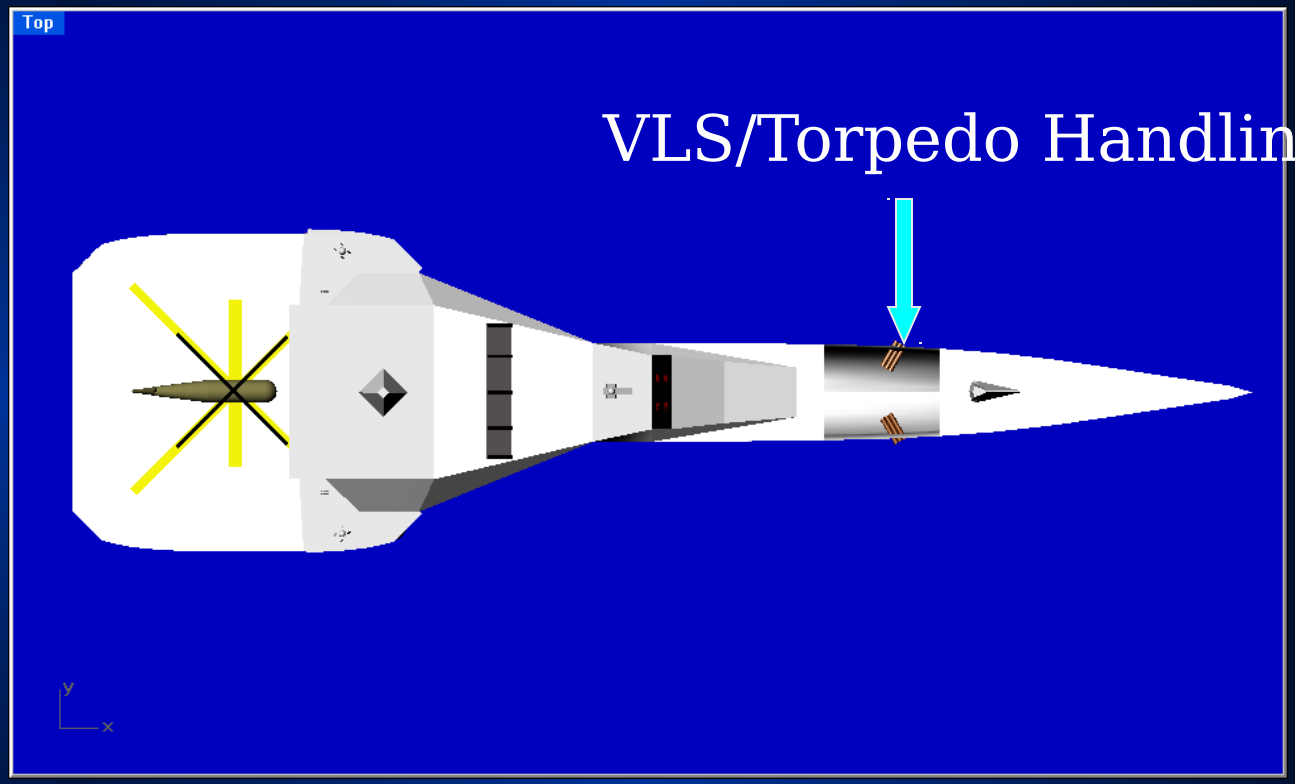
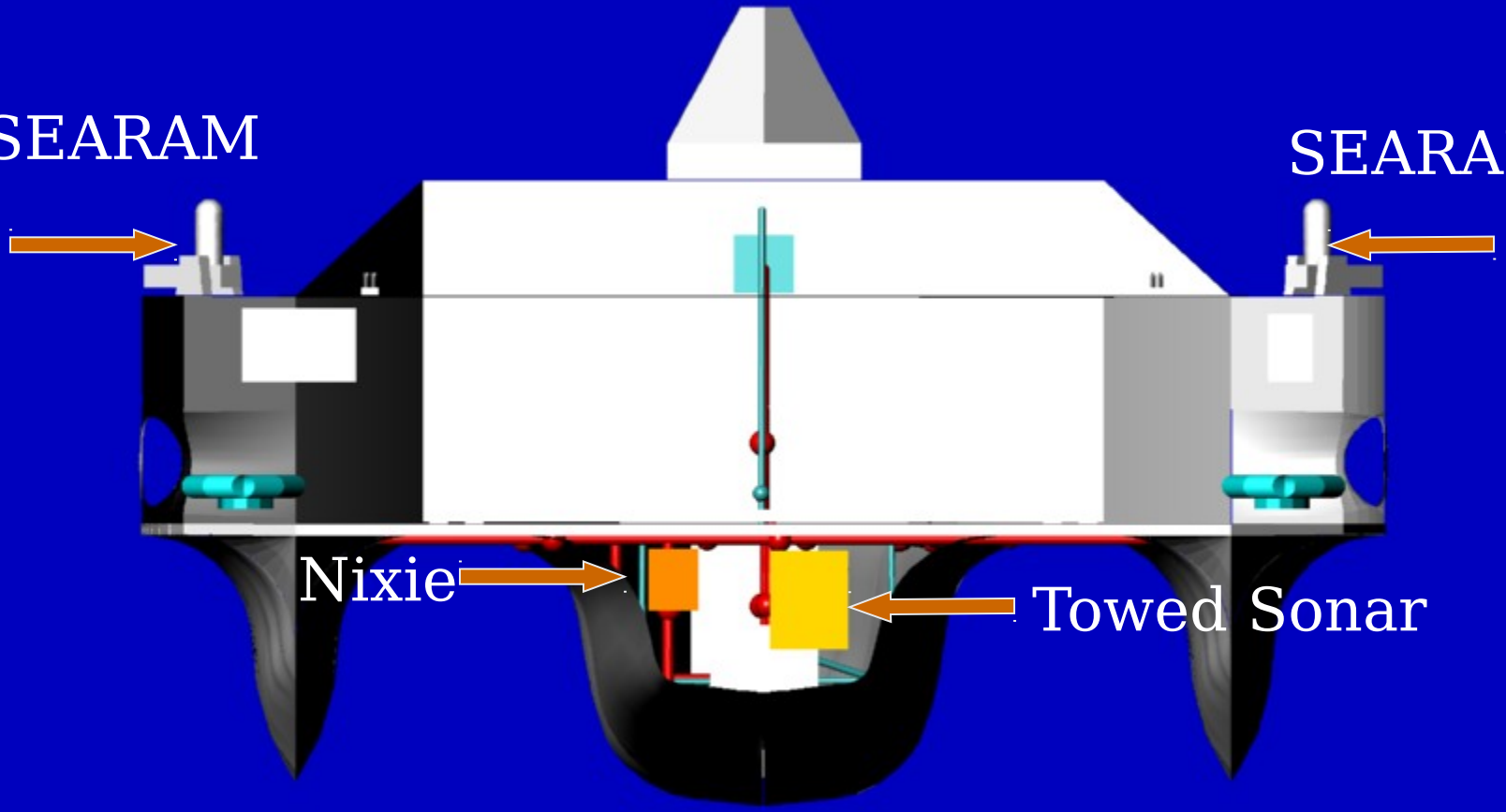
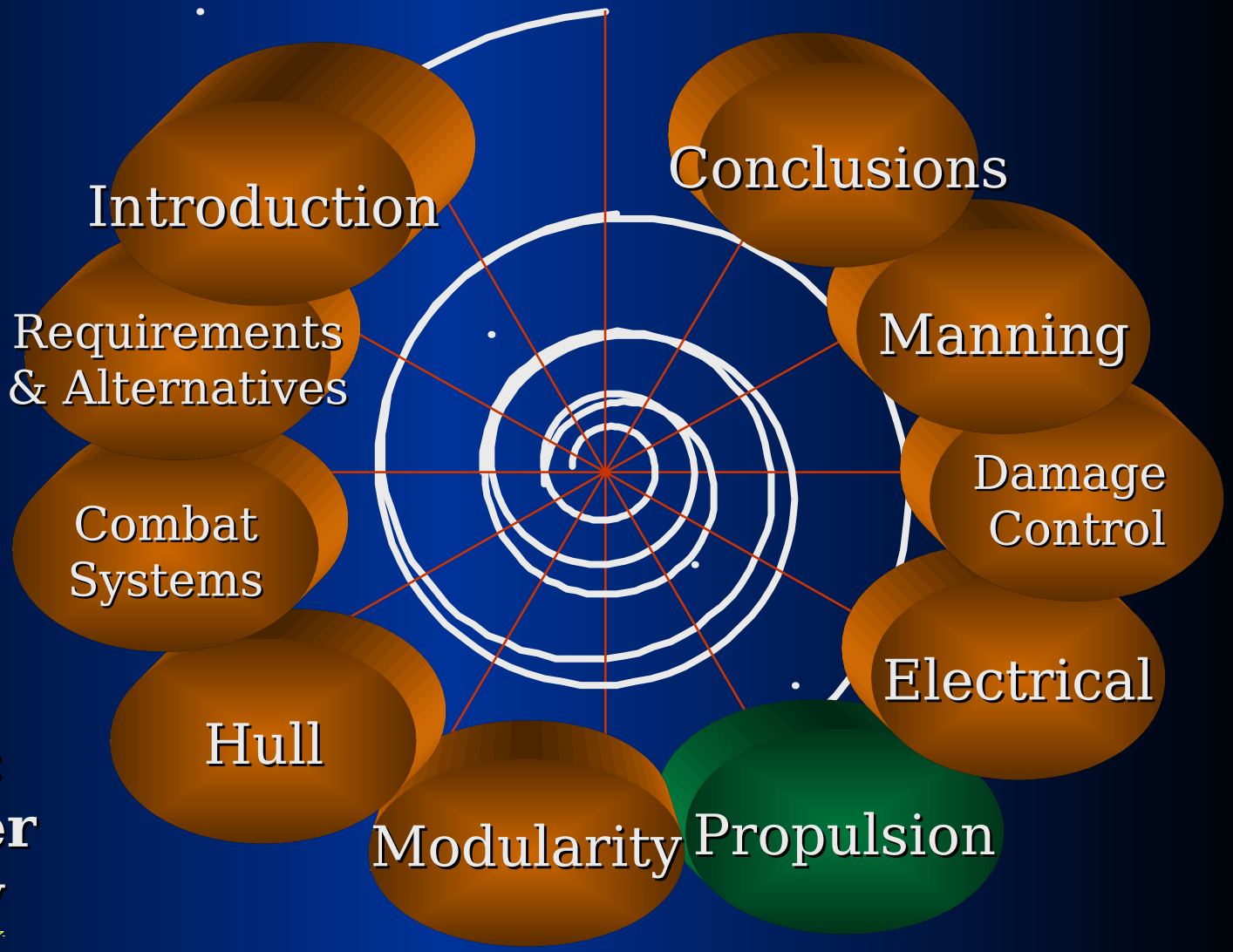


Modularity



Propulsion Design



Next Speaker: LTJG Alper Kurultay

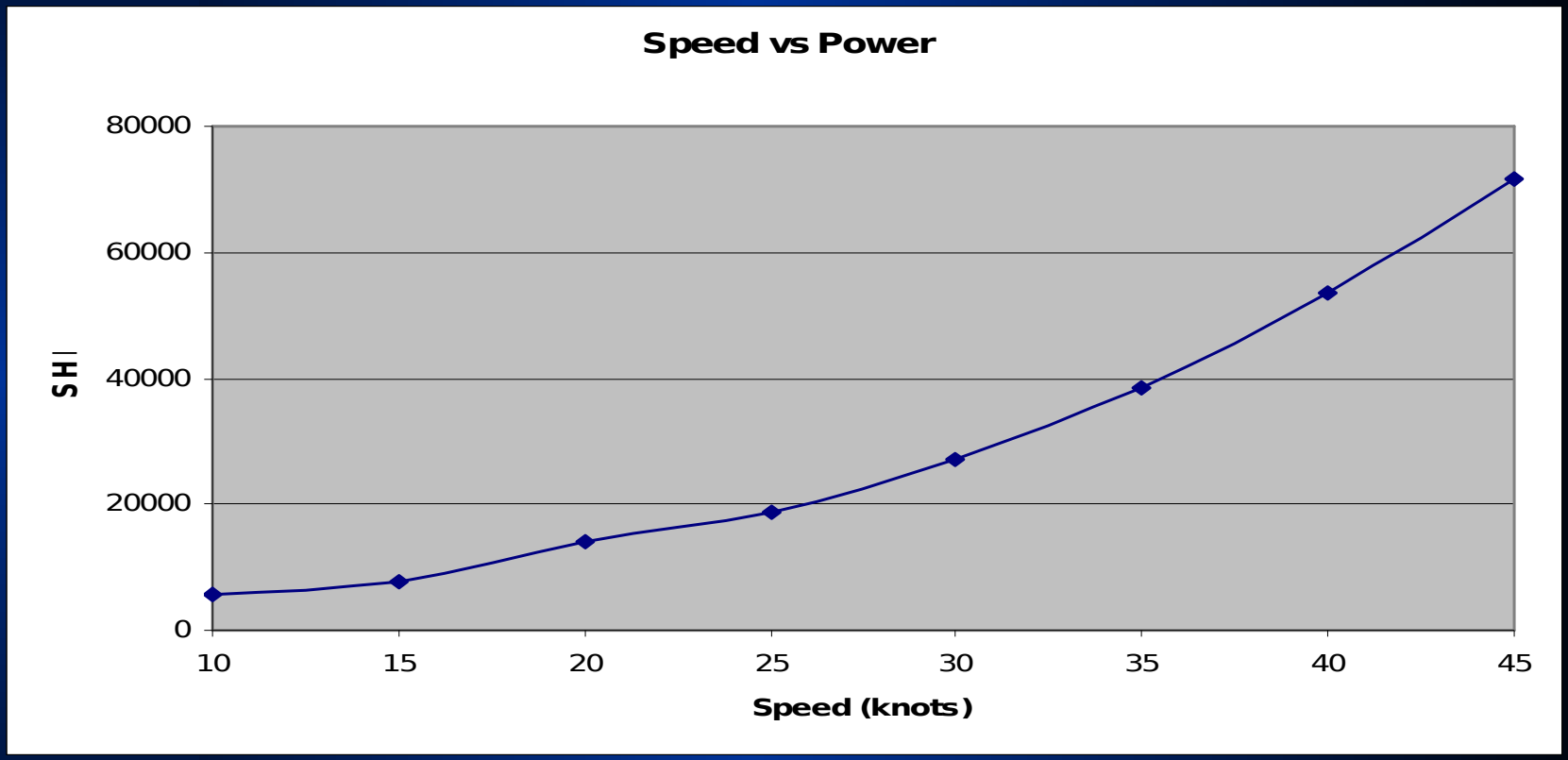
Approach

- Resistance Calculations and Power Requirements
- Selections
  - Propulsion Plant
  - Prime Mover
  - Propulsor
  - Propeller
- Trade-Offs
  - MT 30 vs. LM 2500(+)
  - LM 1600 vs. LM 2500(+) for Endurance Speed Calculations
- Fuel Consumption and Endurance Speed Calculations
- Layout Plan

Resistance Calculations

- Wave Resistance
  - Ship Wave Analysis Code
- Frictional Resistance
  - Based on ITTC57 Formula
- Form Resistance
  - Percent of the Frictional Resistance

Power Requirements



24 Hour Ship Electric Load = 5 000 Hp (~3.7 MW)

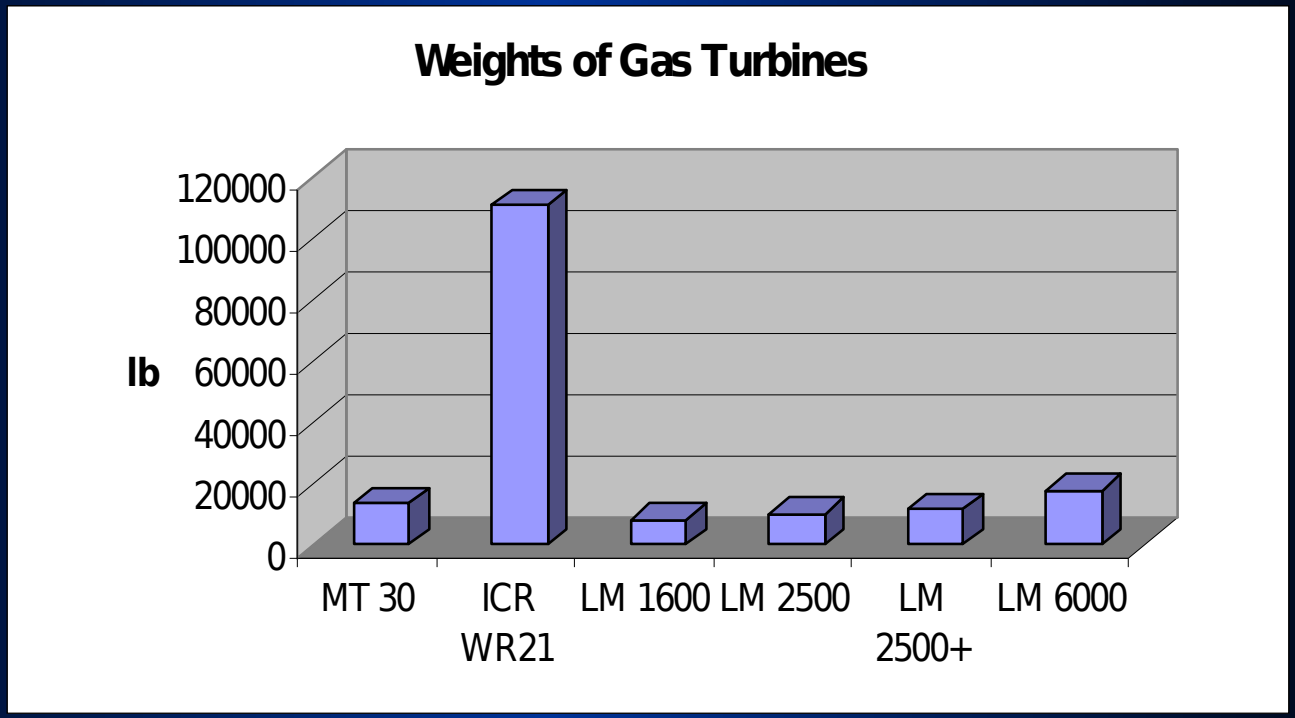
Alternatives for Propulsion Plants

- Conventional Steam Plant
- Nuclear Steam Plant
- Fuel Cells
- Diesels
- Gas Turbines

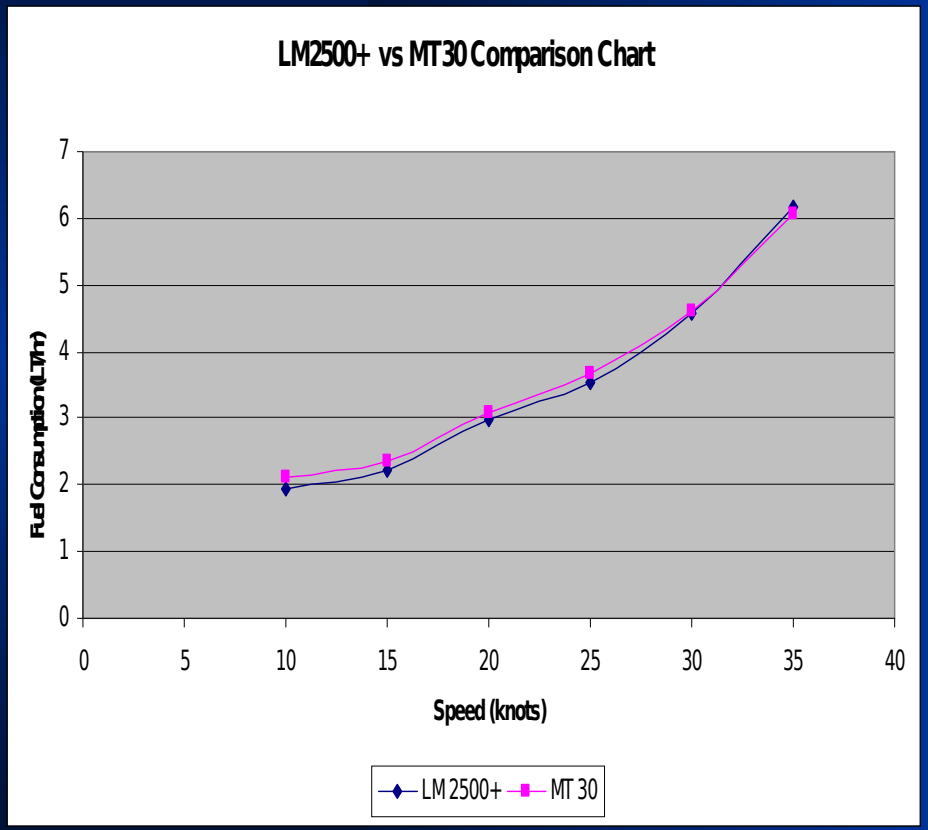
Prime Mover Selection

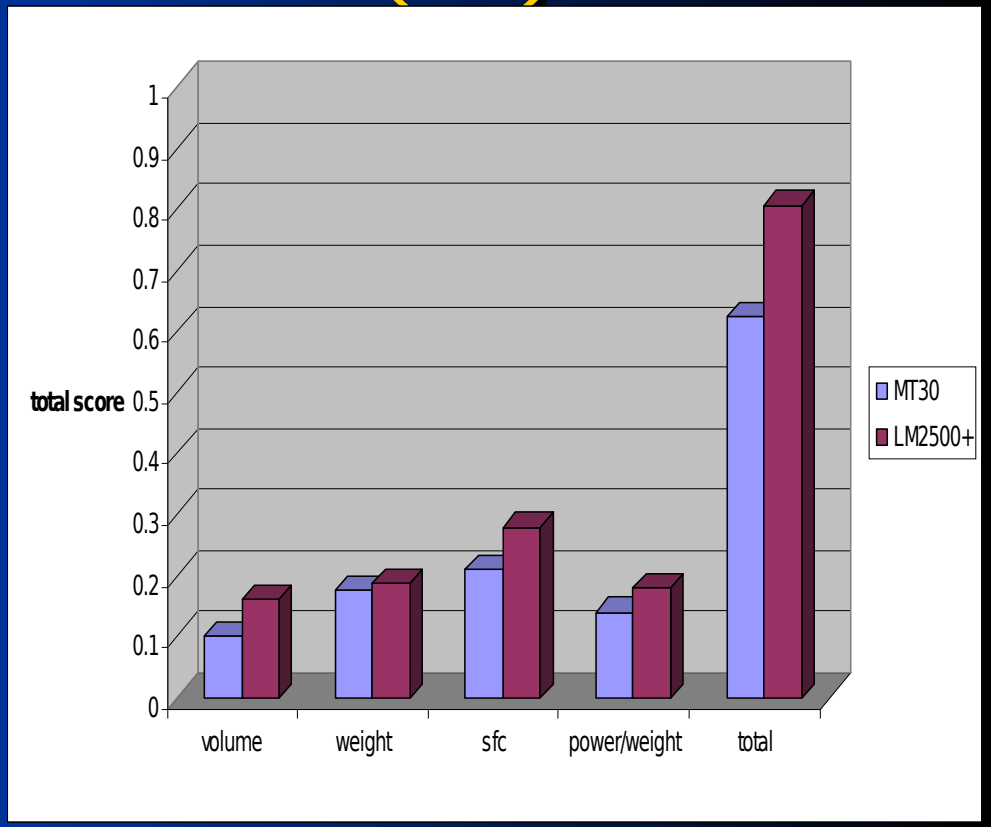
- ICR WR21
- LM 1600
- LM 2500
- LM 2500+
- MT 30 Trent

Comparison of Gas Turbines



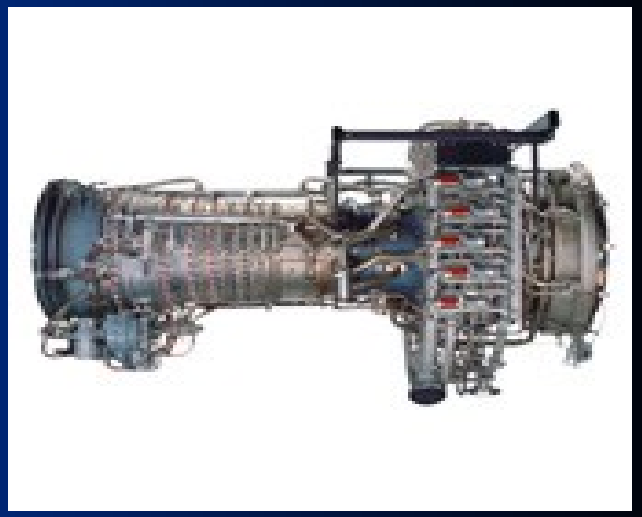
Trade Off Study Between MT30 and LM2500(+)

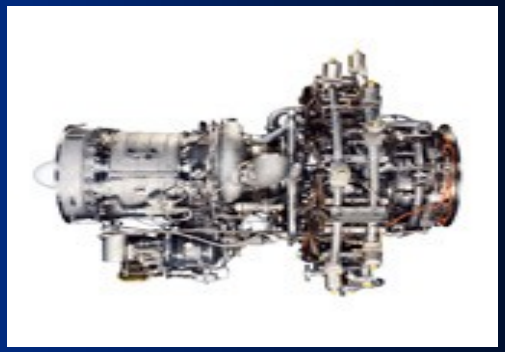




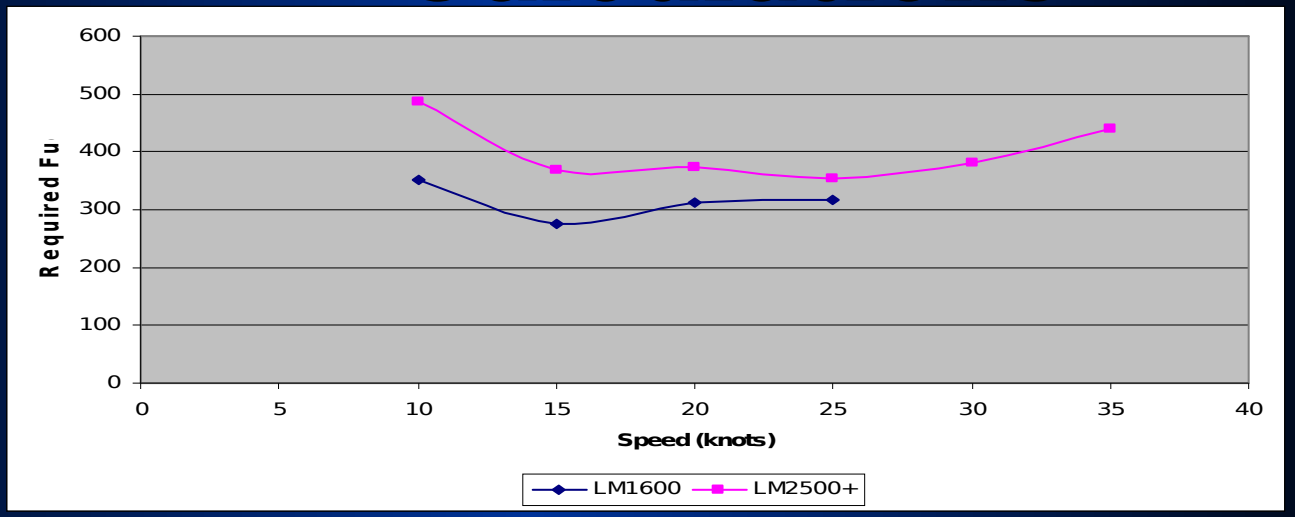
Final Decision

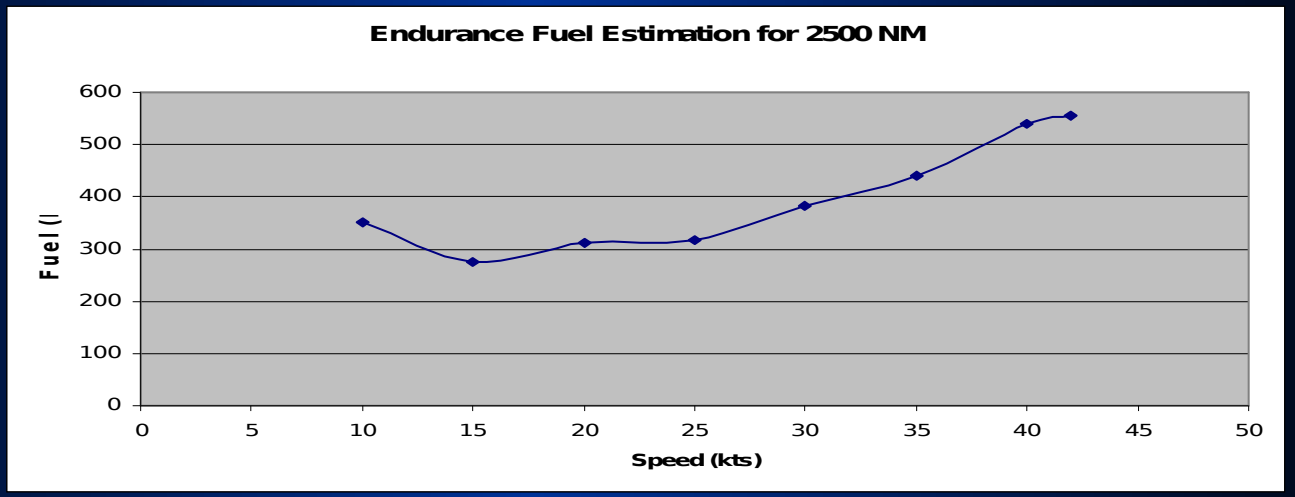
- 1 LM2500+
- 1 LM1600
- 1 Allison AG9140 (Harbor Duty)





Fuel Consumption Calculations

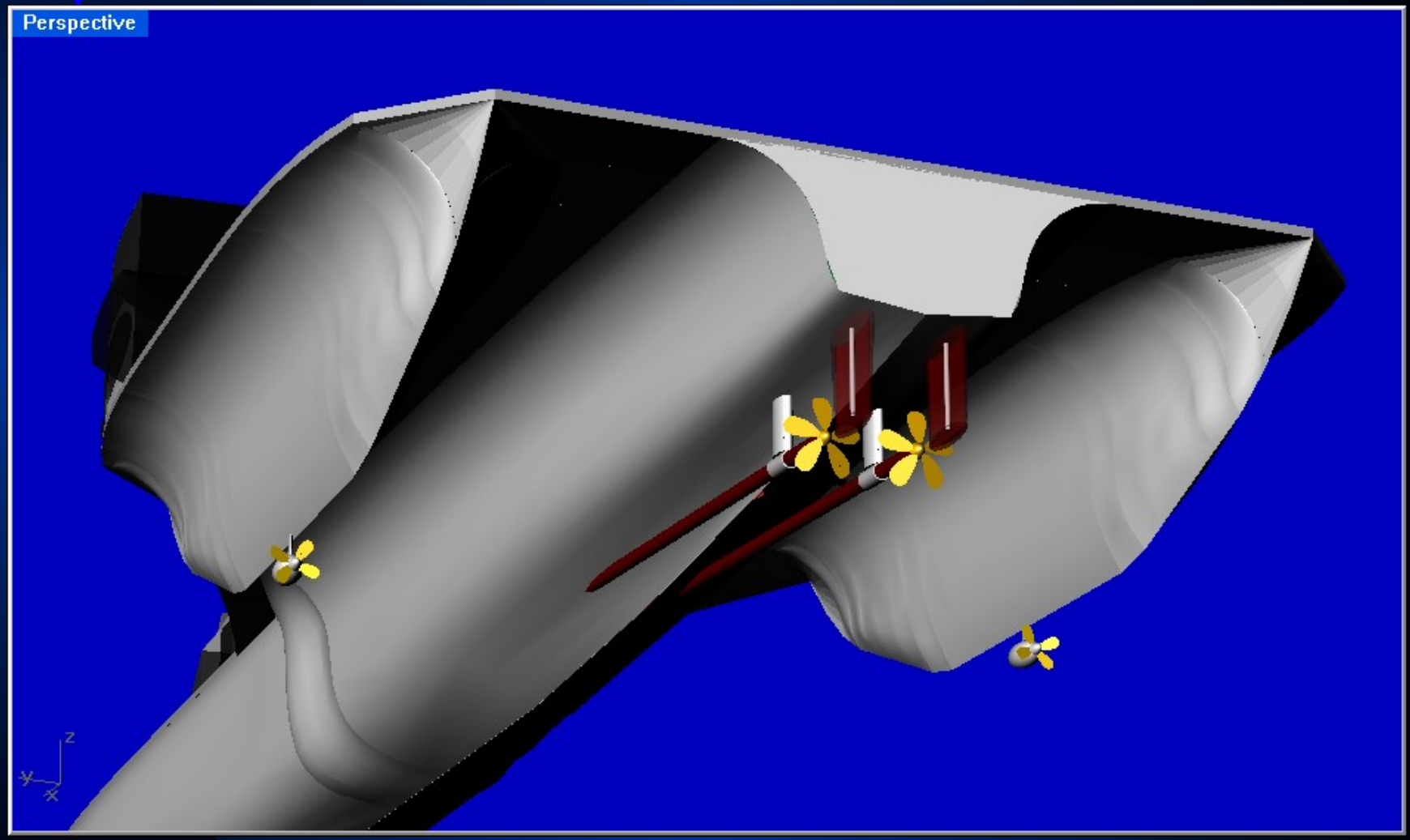




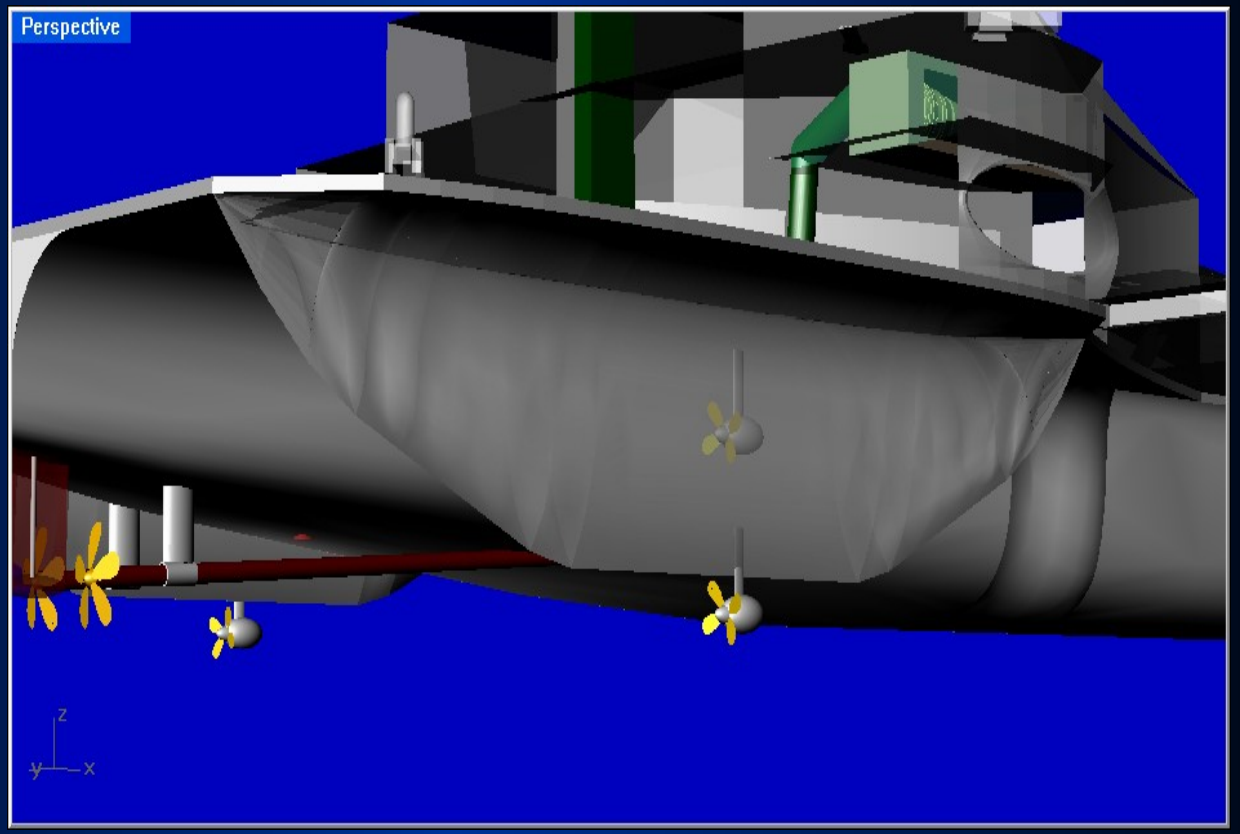
Propulsor Choices

- Podded Propulsors
- Water jets and hydro drive
- Conventional Propeller

Propeller Selection



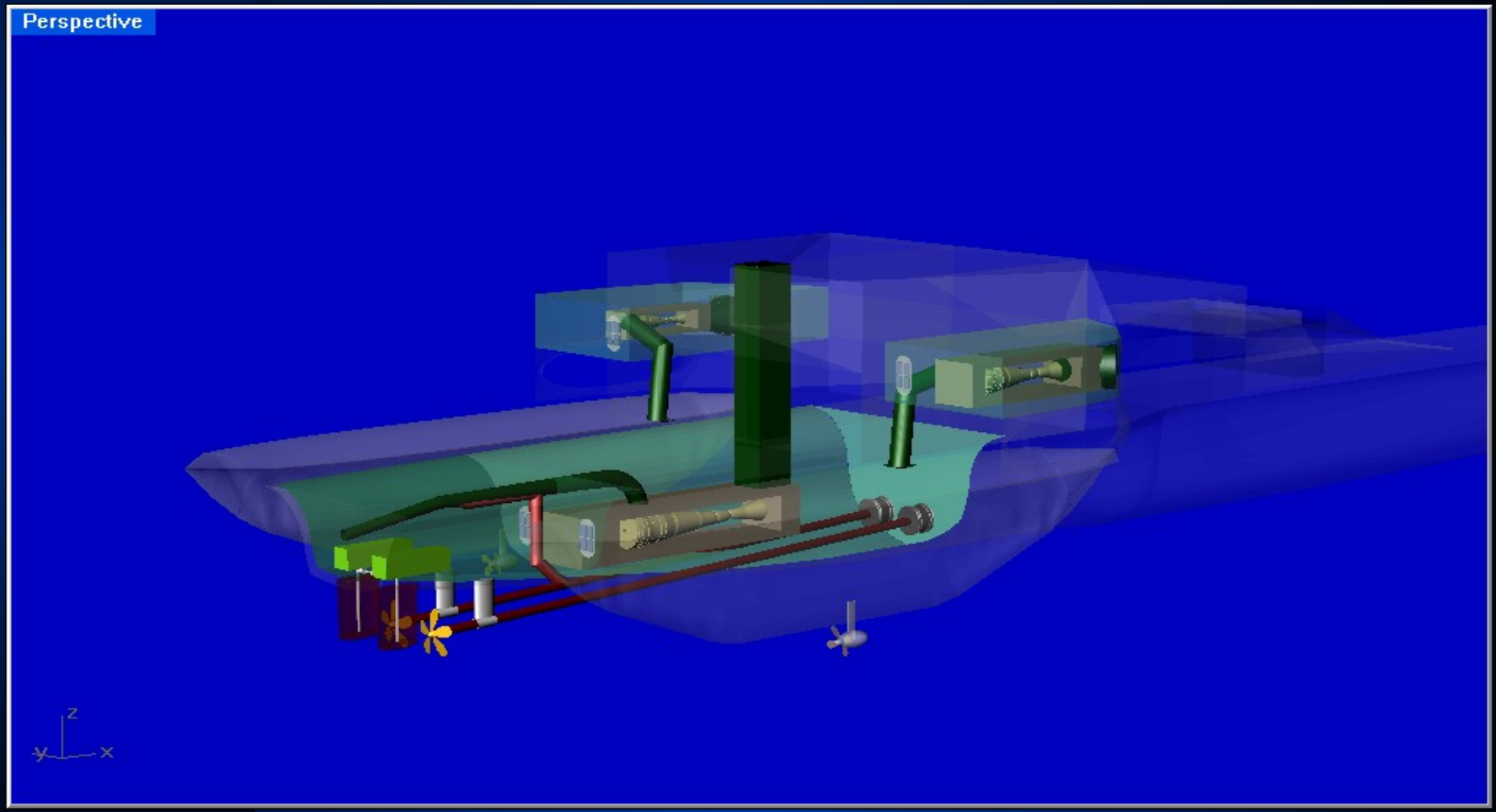
Retractable Rudder Propellers



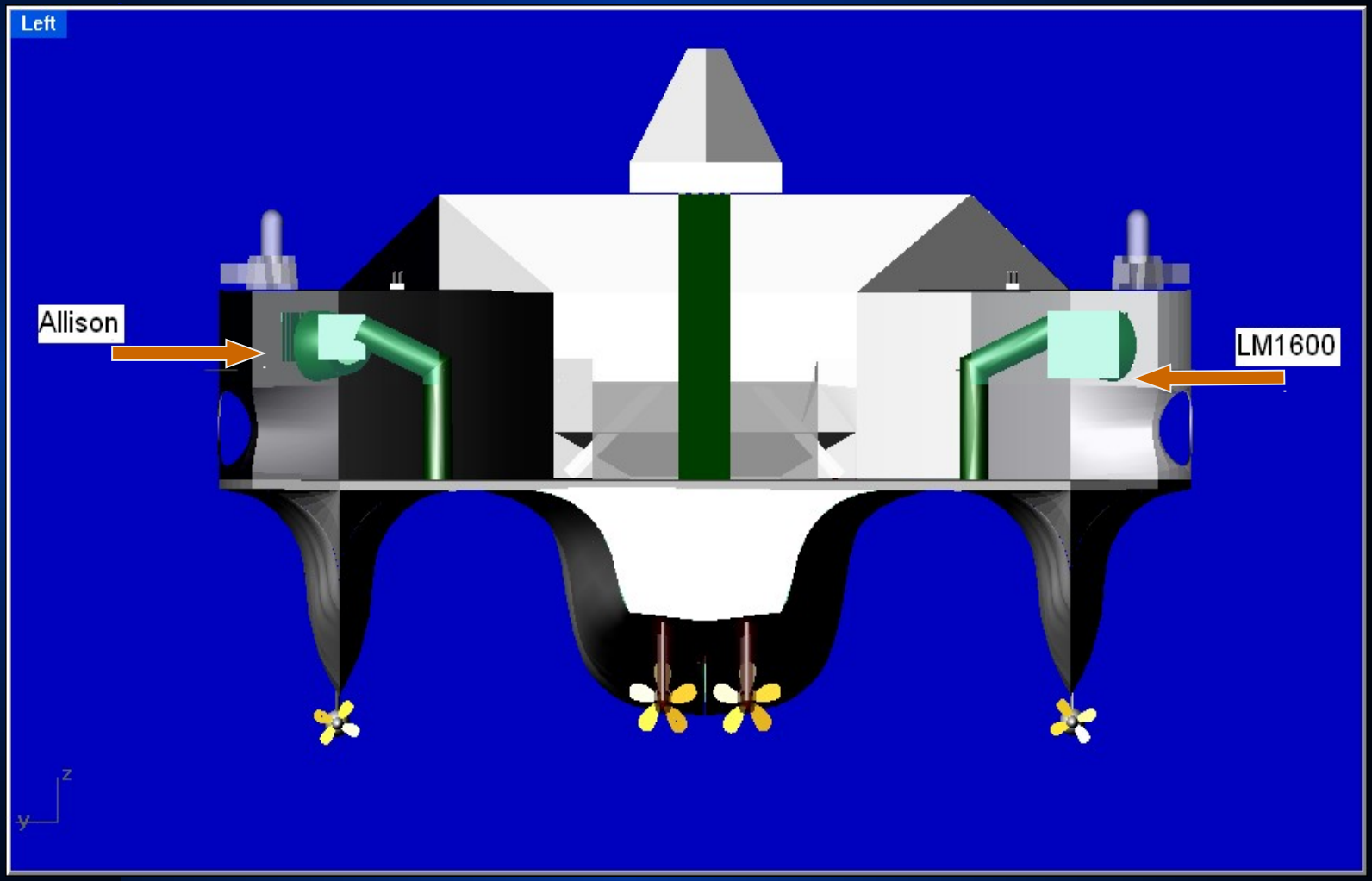
Propulsion Motor Selection

- Conventional motors
- HTS AC synchronous motors
- DC Super Conducting Homopolar motors

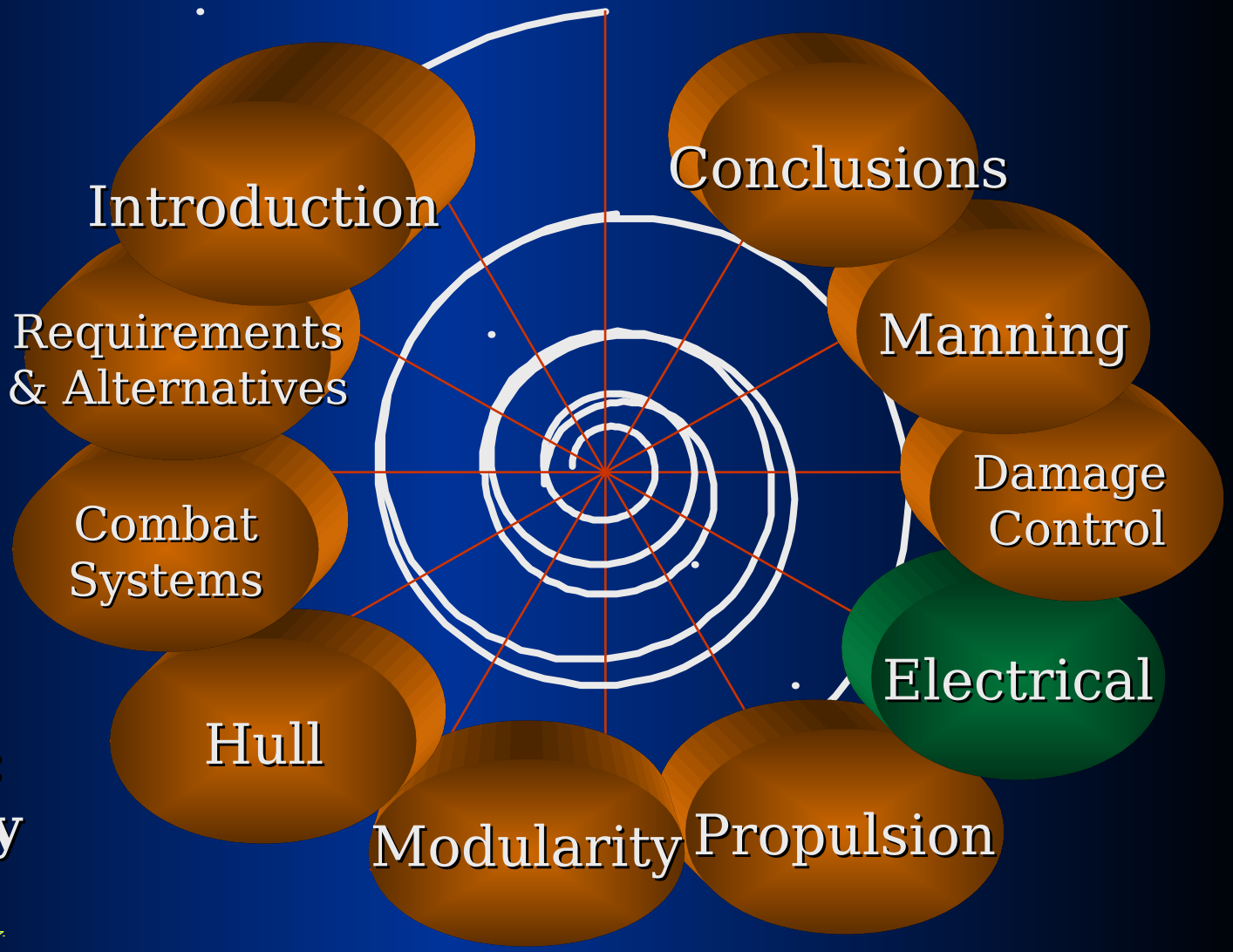
Engine Rooms Layout



Engine Rooms Layout

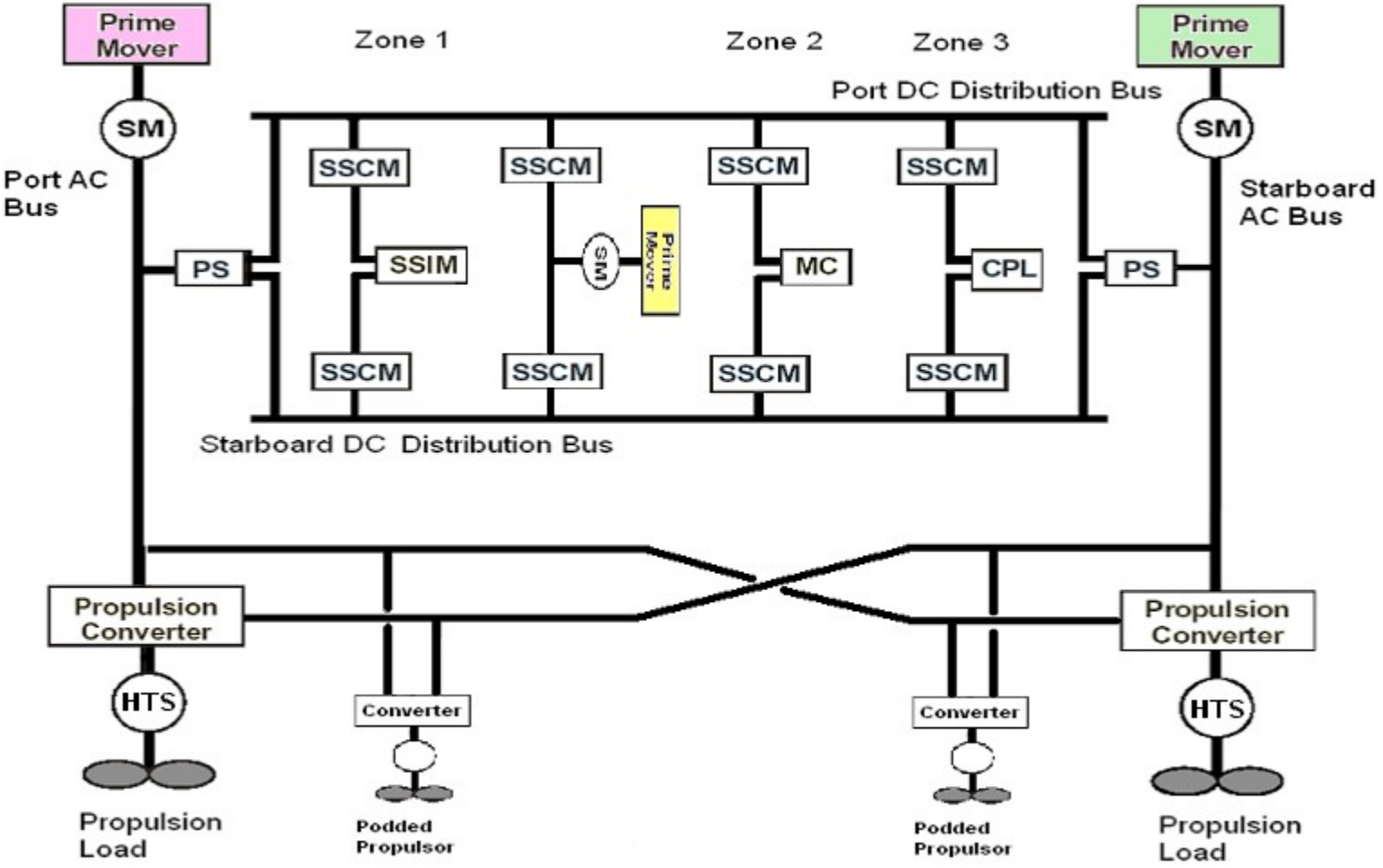


Electrical Distribution

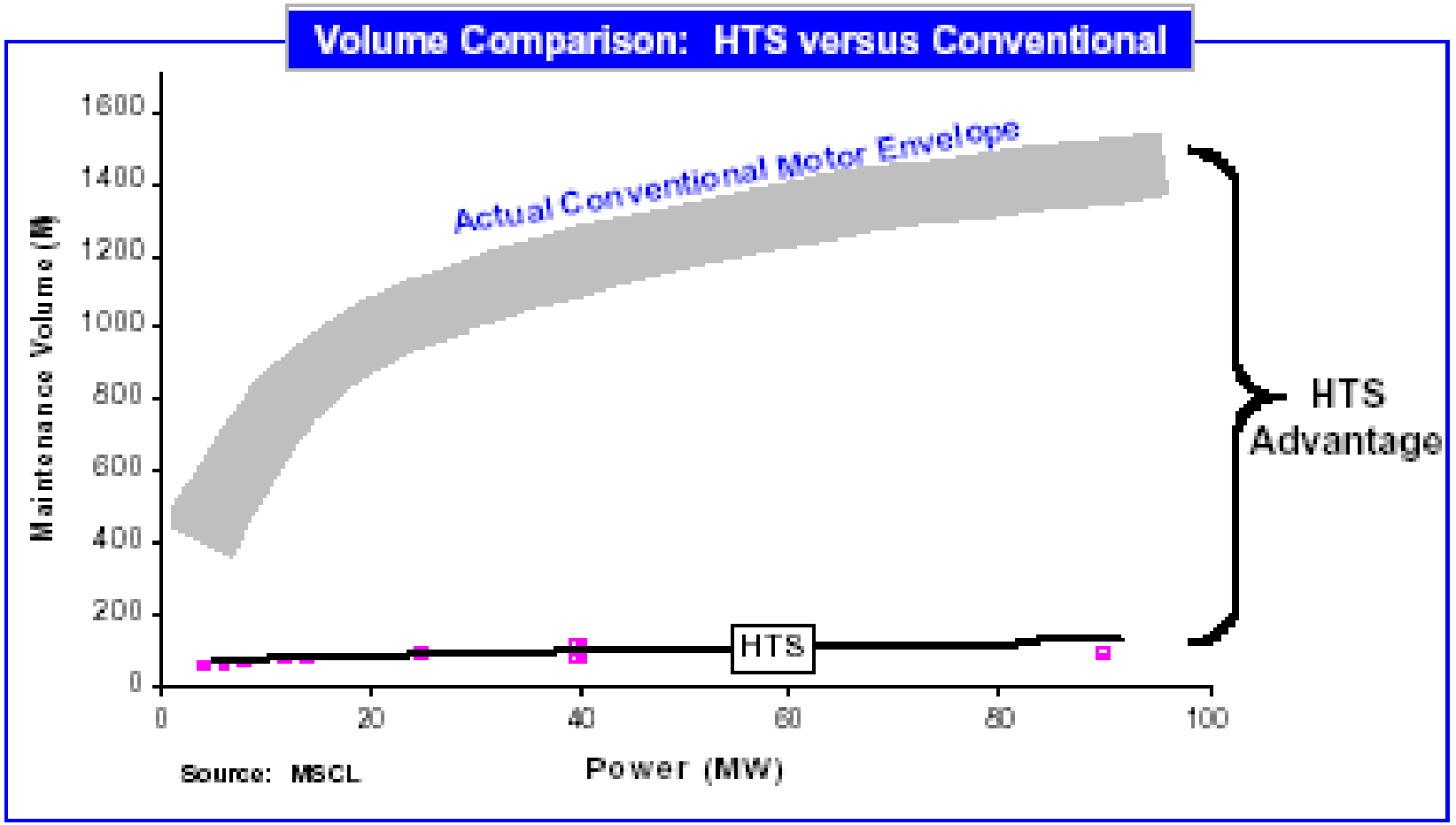


Next Speaker: LT Freddy Santos

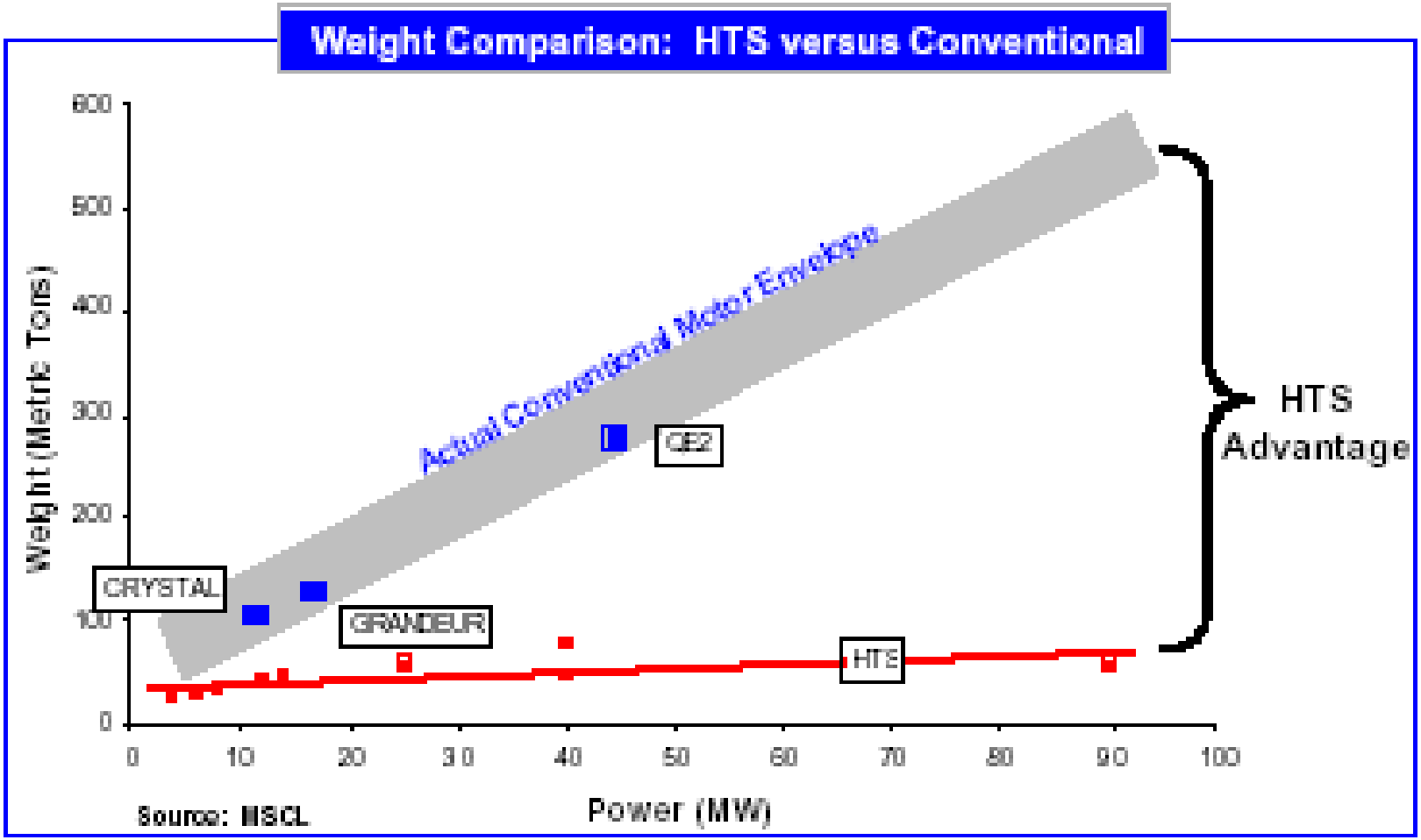
Electrical Distribution



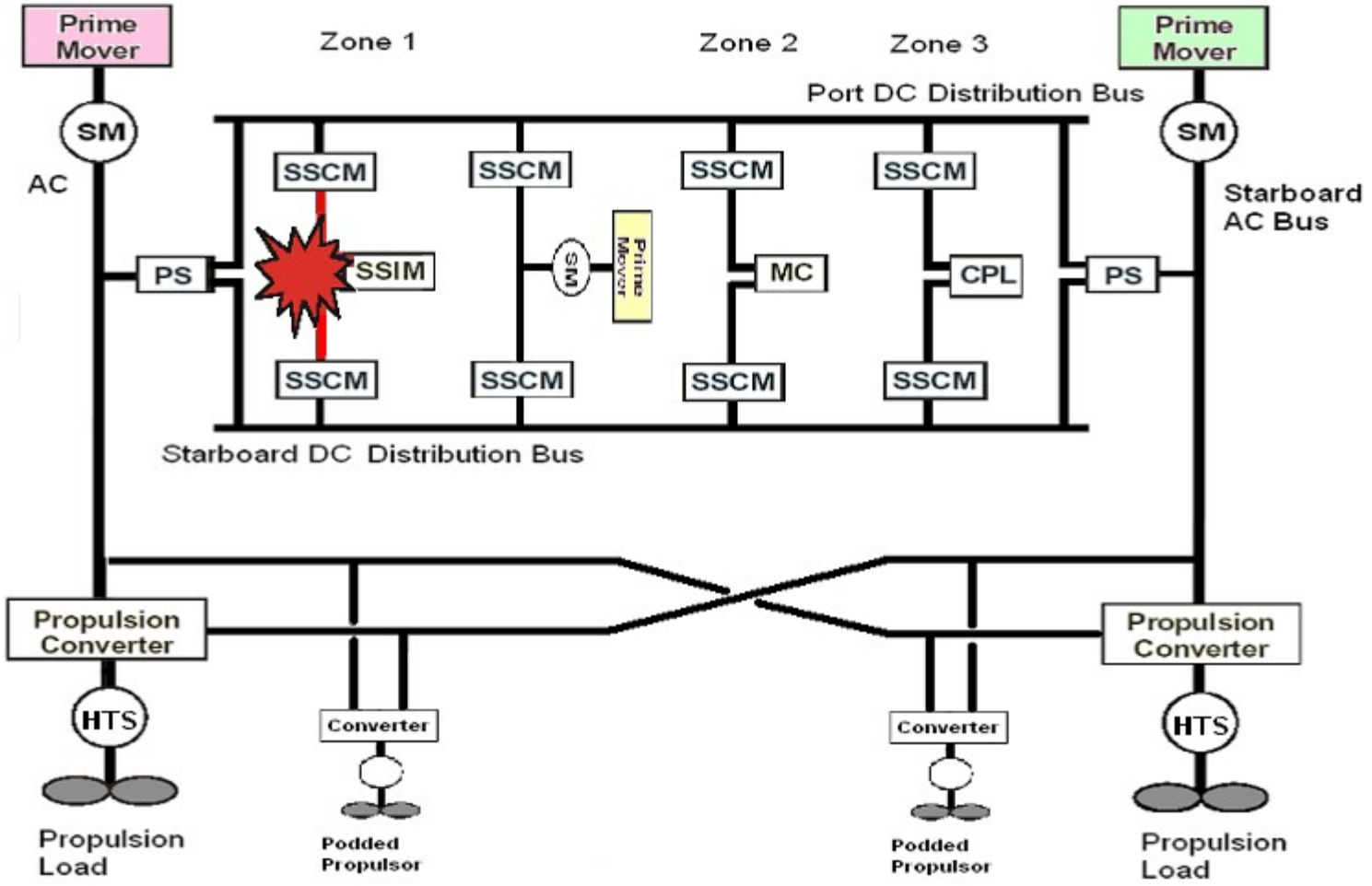
Electrical Distribution



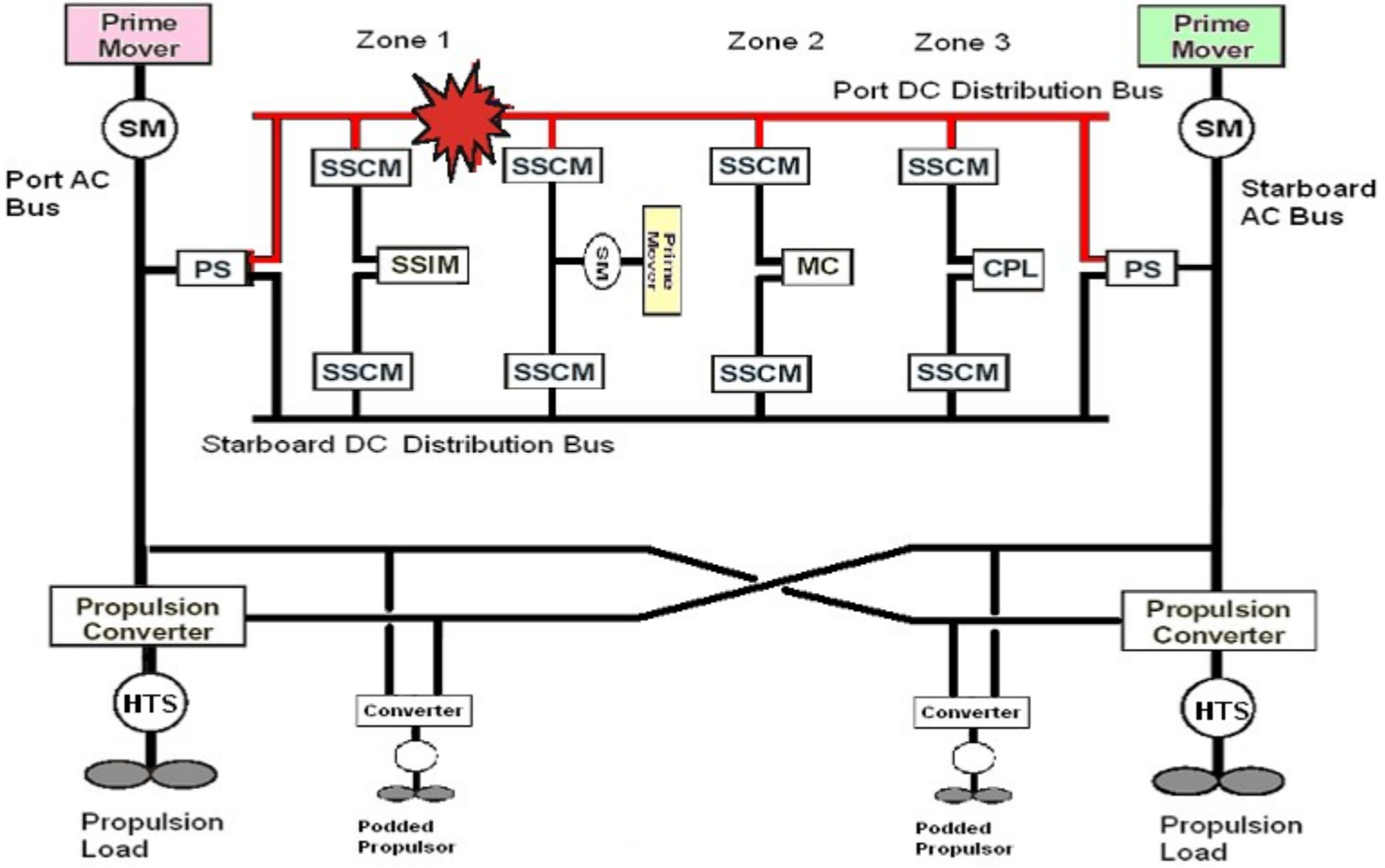
Electrical Distribution



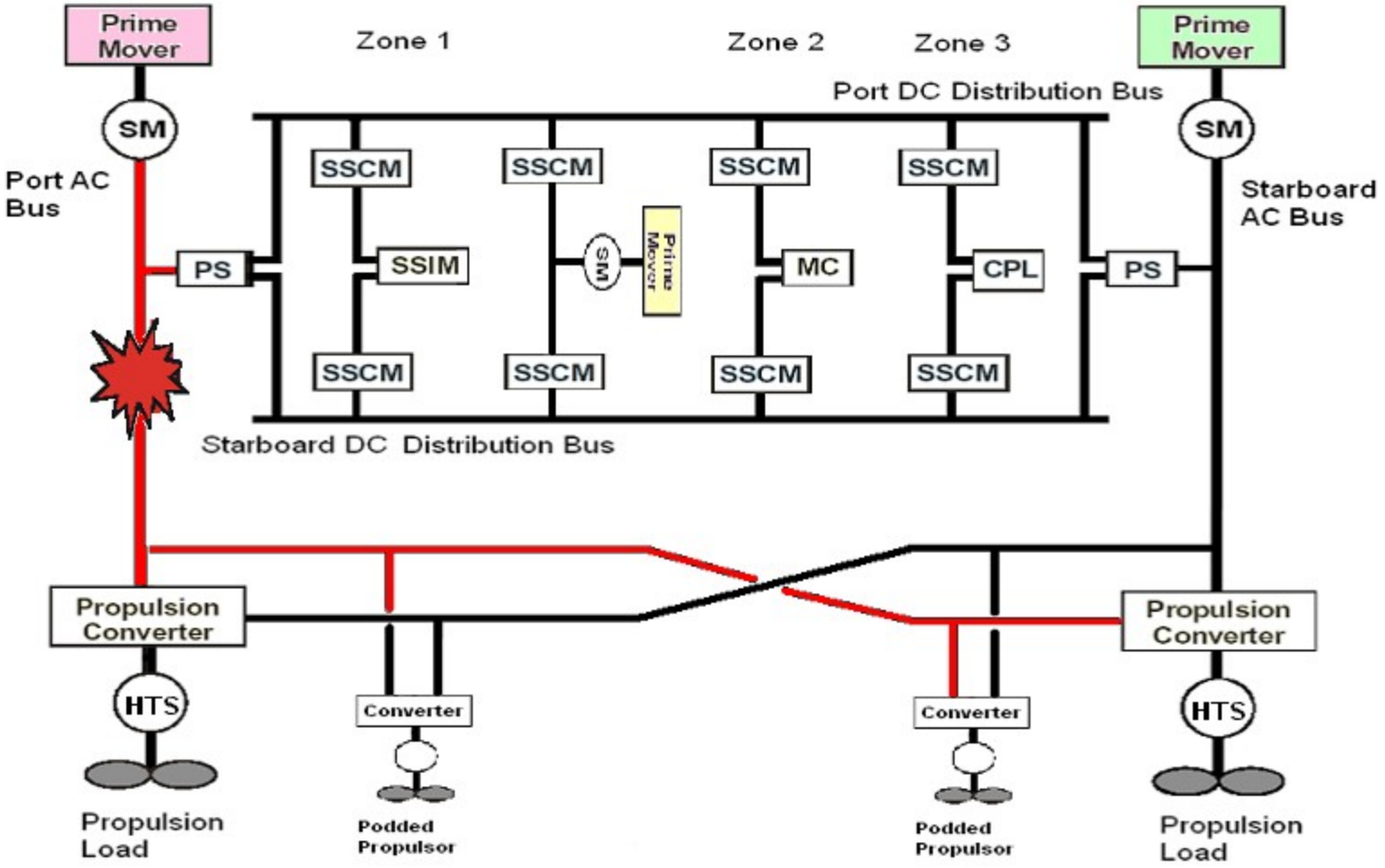
Electrical Distribution



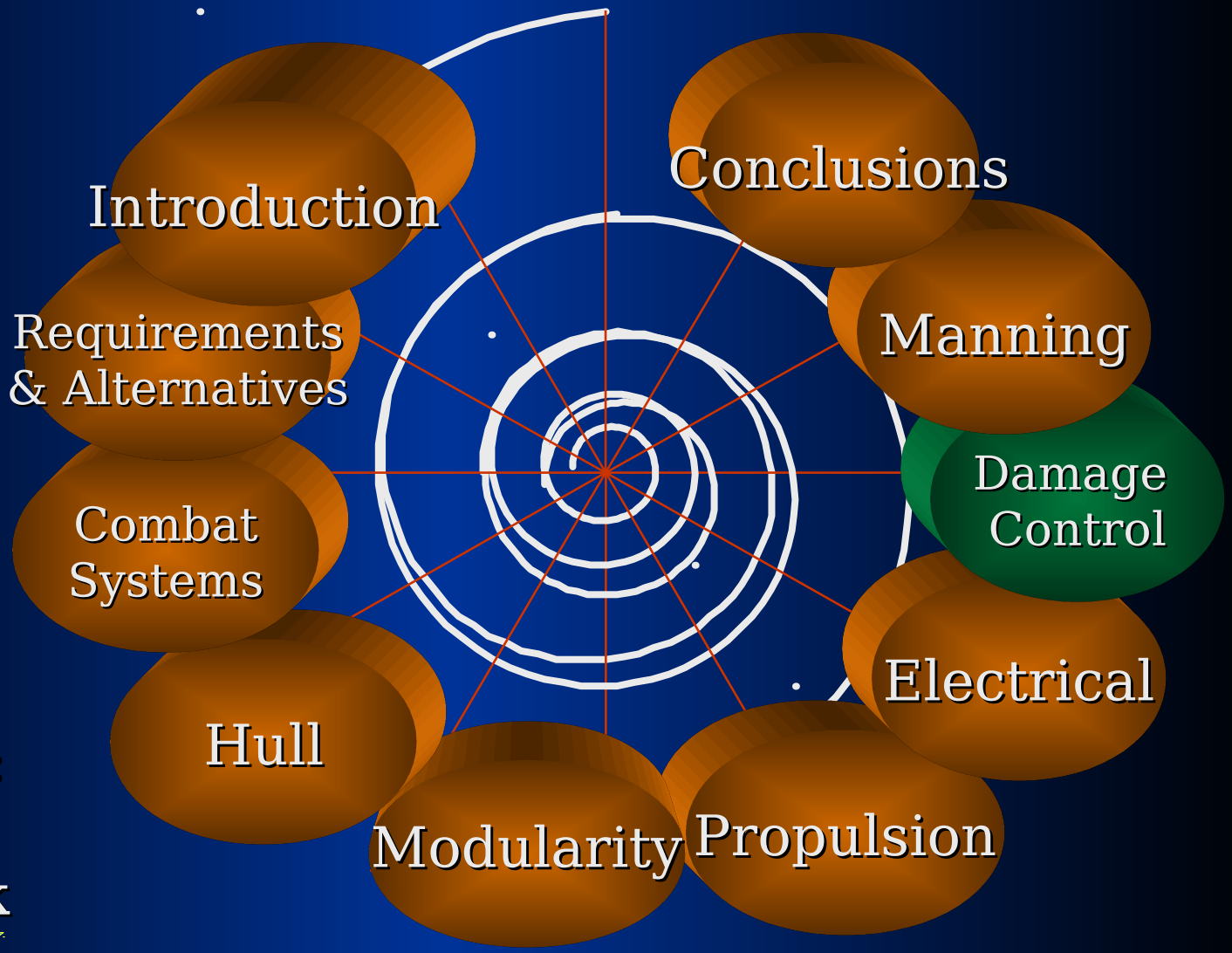
Electrical Distribution



Electrical Distribution



Damage Control



Next Speaker: LT Jake Didoszak

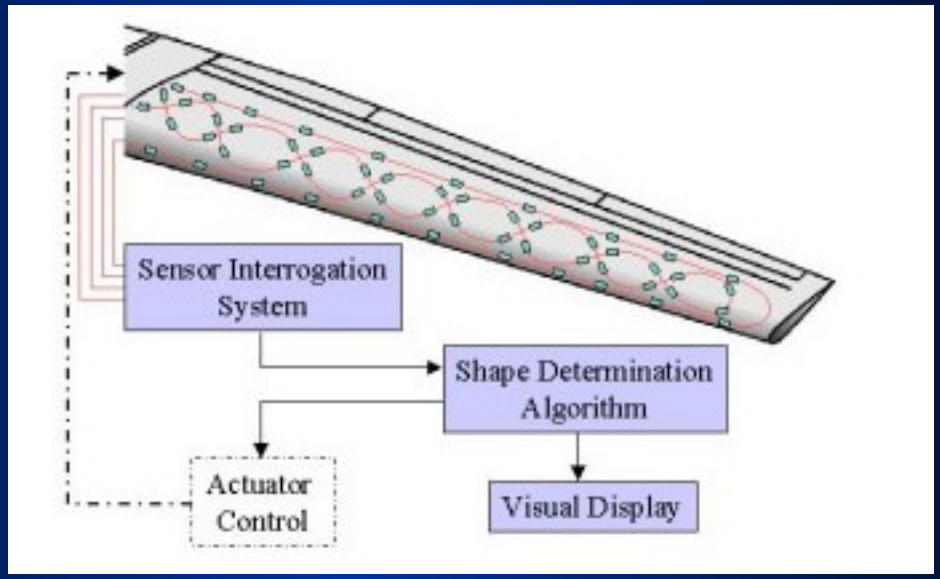
Damage Control Philosophy

Prevent Casualties

- Shipboard Virtual Reality DC Training
- Integrated Zonal Compartmentalization
  - Electrical
  - Mechanical
- Remote Sensing Systems
  - Embedded Damage Sensing Syst
  - Space CCTV/Video Monitoring
  - Point Detection System (CBR)

Evolving Technologies

- Fiber Optic Embedded Wing Shape Sensing



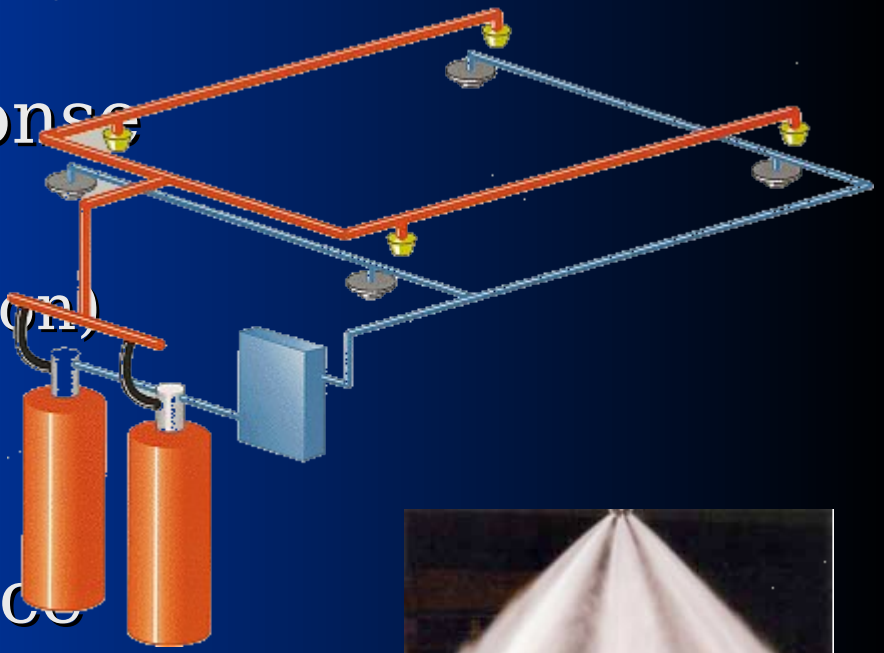
- EmberNet Wireless-Networking System
- Embedded Temperature Sensing
- Infra-Red Flame Detection Sensors

Damage Sensor Matrix

Compartment	Infra-red	CCTV/ Video	Liquid Level	Fiber Opt/ Embedded
CIC	X			
Bridge	X			
Offices	X			
Berthing	X		X	X
Galley & Messing	X	X		
Passageways	X			X
Electronics rooms	X	X		
Pump rooms	X	X	X	X
AC&R rooms	X	X	X	X
Paint lockers	X			
Engine enclosures	X	X		
Machinery spaces	X	X	X	X
Magazines	X	X	X	
Hangar	X	X		
Flight deck		X		

Combat Casualties (FIRE)

- Automated First Response
  - Water Mist System
  - FM-200 (Fire Suppression)
  - CO_2 Flooding
  - AFFF
- Human System Interface
  - Personnel tracking system
  - Shipboard Wide Area Network
  - SEED for all watchstanders



Automated Response Matrix

Compartment	FM 200	CO2	Water Mist	AFFF
CIC	X			
Bridge	X			
Offices	X			
Berthing			X	
Galley & Messing			X	
Passageways			X	
Electronics rooms	X	X		
Pump rooms	X	X		
AC&R rooms	X	X		
Paint lockers	X	X		
Engine enclosures	X	X		
Machinery spaces	X	X	X	X
Magazines			X	X
Hangar			X	X
Flight deck				X

Combat Casualties (FIRE)

- Automated First Response
  - Water Mist System
  - FM-200 (Fire Suppression)
  - CO_2 Flooding
  - AFFF
- Human System Interface
  - Personnel tracking system
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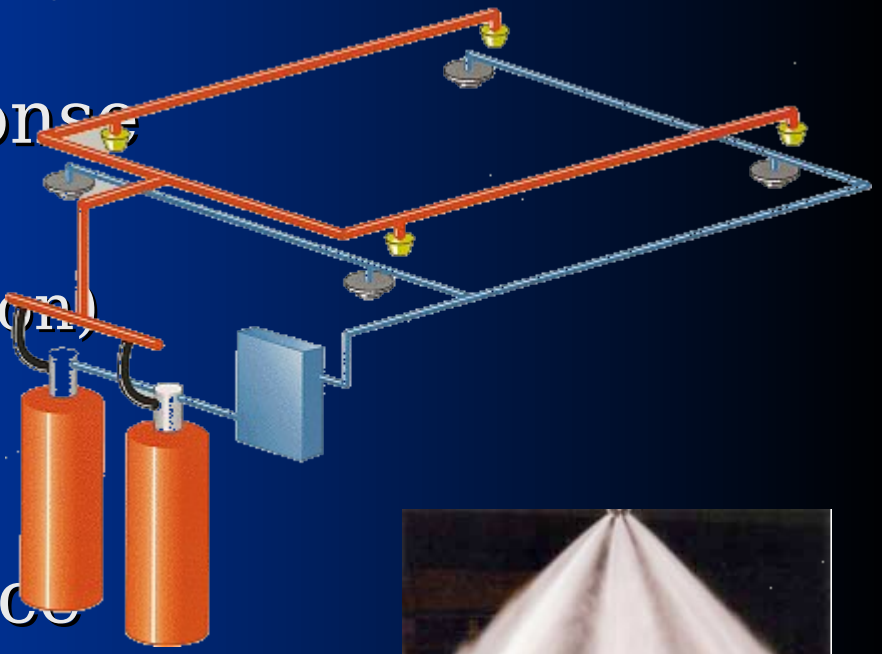
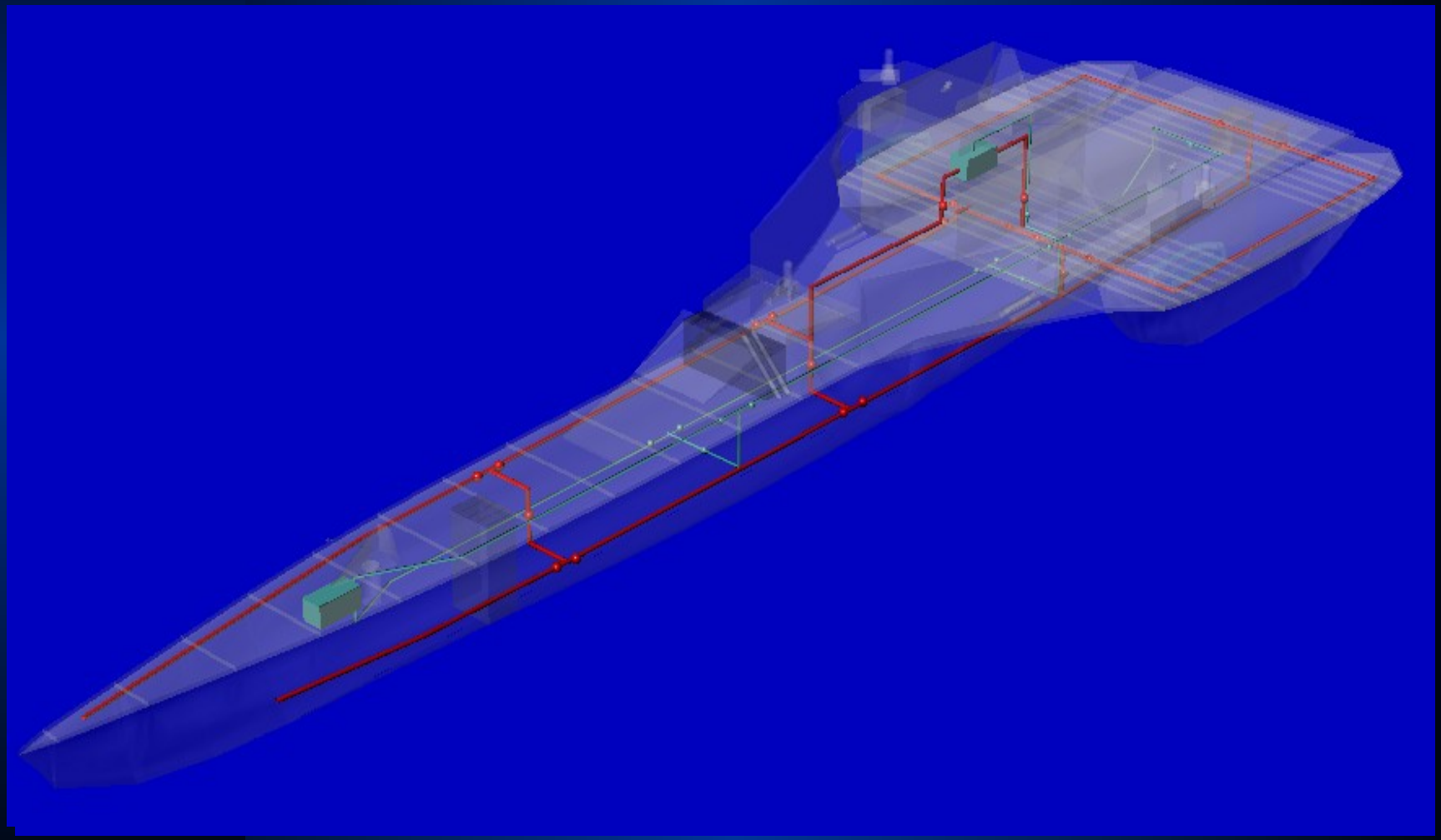


Firemain and AFFF Systems



Combat Casualties

- Damage Control Parties
  - Two Repair Lockers
  - Video/sensor investigatio
  - Secondary line of respons

- Utilityman cross-training
- Reduced overall manning

Restore from Casualties

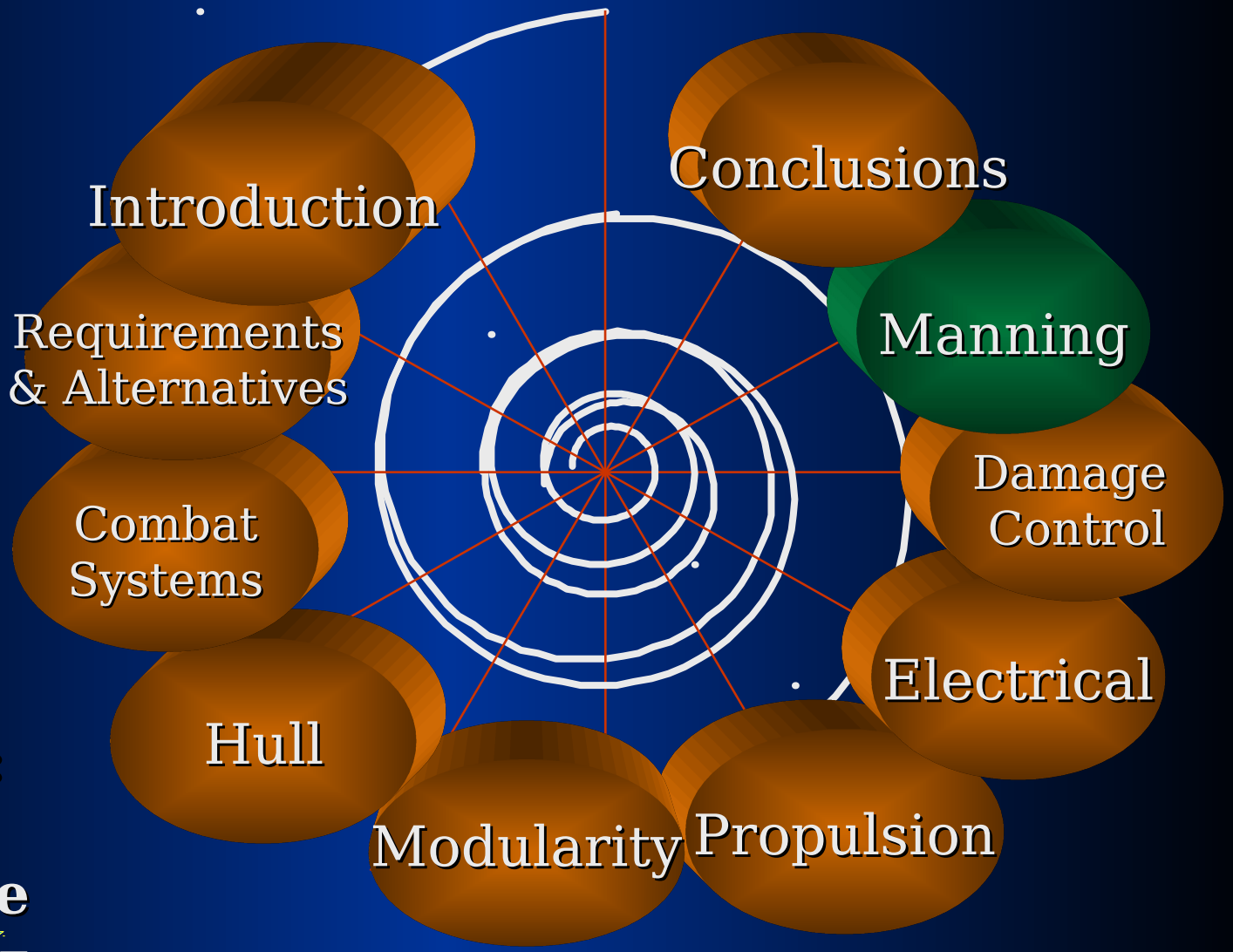
- Zonal systems
  - Damage Control (FM, AFFF, CPS)
  - Mechanical (CW, VENT, compartment isolation)
  - Electrical (integrated distributed power grid)
- Self-healing systems
  - Buoyancy foam filler
  - Quickset patches
  - Kevlar cladding
  - Installed smoke ejectors
  - Installed drainage and educ

CBR – Layered Defense

Damage Control Summary

- Increased use of Automatic response systems
- Real-time situational awareness through SWAN
- More unmanned machinery/electrical spaces
- Model & Simulate to predict damage progression
- Use of COTS Damage Control systems
- Greater survivability through better compartment/zonal segregation

Reduced Manning



Next Speaker: LT Constance Fernandez

Reduced Manning

- Manning levels determined based on
  - Watch Stations
  - Maintenance
  - Logistics Operations requirements
- Focused on Reduced Manning
  - Low maintenance design
  - Increased skill level of crew

Reduced Manning

Condition I Watch Bill

STATION LOCATION	AAW	USW
PILOT HOUSE/SIGNAL BRIDGE	3	3
CO/XO	2	2
COMBAT	9	9
AAW	3	
USW		4
WEAPONS/SUPPORT	11	11
CCS/DC	4	4
ENGINEERING	7	7
REPAIR 1	21	21
REPAIR 2	21	21
FLIGHT DECK	5	5
HELO FIRE FIGHTING	11	11
HELO DETACH		
CORPSMEN	6	6
MESSING	4	4
SUPPLY	4	4
TOTAL	111	112

	AAW	USW
Without Repair Parties	54	55
2 Section Rotation	108	110
Repair Parties	57	57
Required Manning	**165**	**167**
Required Berthing (Helo Detachment of 10 persons)	175	182

SHIP	LENGTH (FT)	CREW
FFG -7	445	300
DDG-51	505	320
TRIDENT	560	175

Reduced Manning

- MAINTENANCE:
  - Condition Based Maintenance
- COMBAT SYSTEMS:
  - Multi-function Radar - two maintenance men, no operators
  - Software for system is “self-diagnostic” and “self healing”
- ENGINEERING:
  - Integrated Electric Drive
  - Electrical Distribution System (fully automatic)

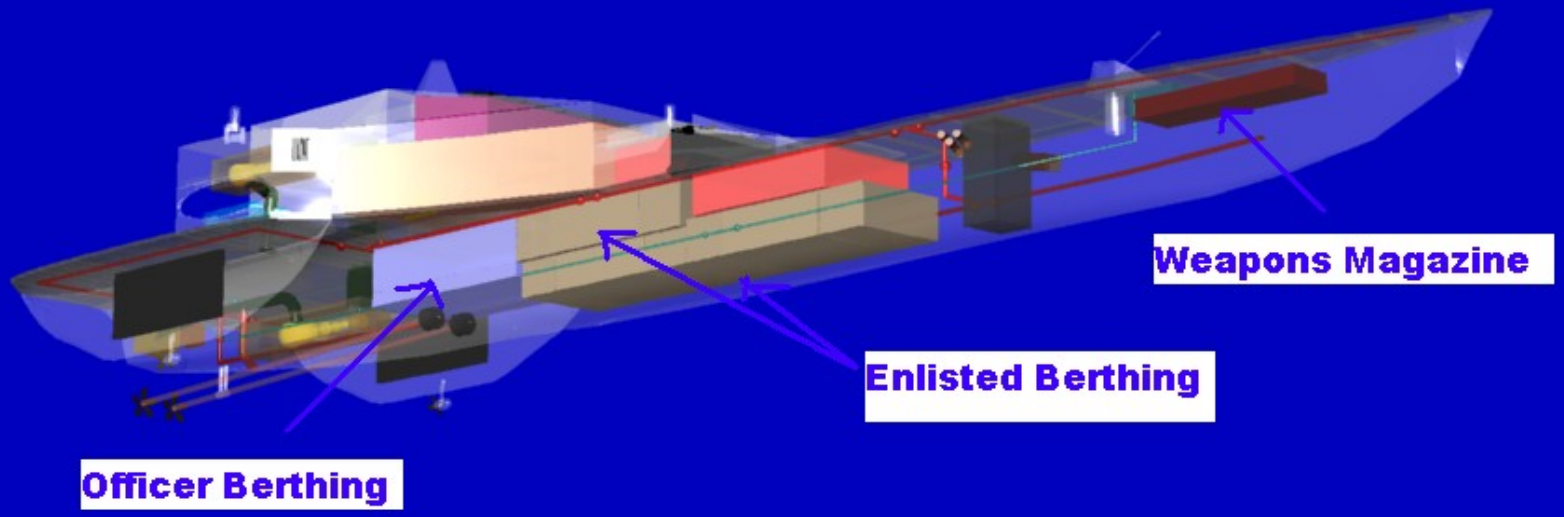
Reduced Manning

- DAMAGE CONTROL:
  - SWAN(Shipboard Wide Area Network)
    - Automated Identification Technology
    - Information Systems
    - Sensors
  - Virtual Training
  - Automated Response
  - Systems that are “self-diagnostic” and “self healing”

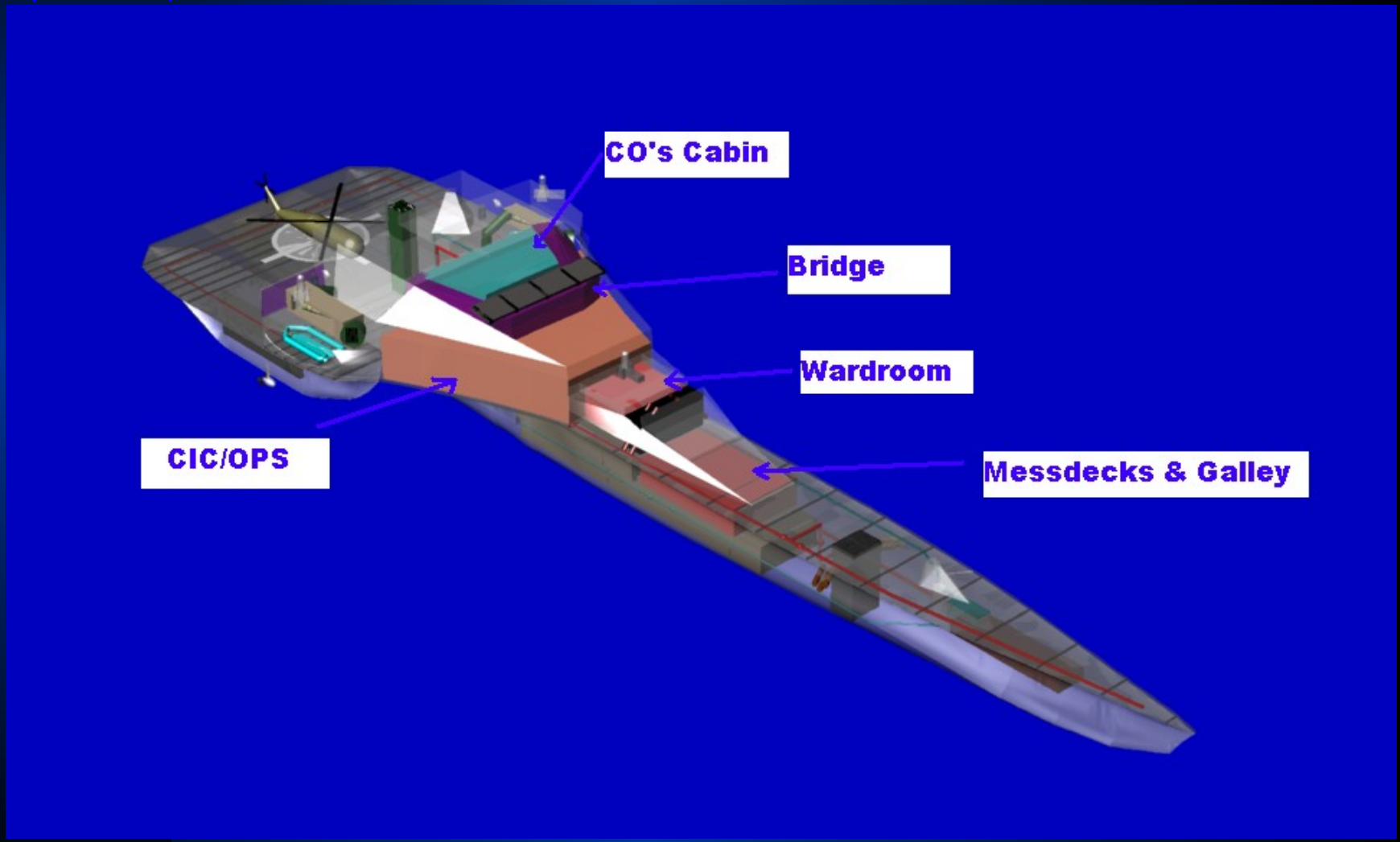
Reduced Manning

- Summary of Reduced Manning
  - Low maintenance/operator design
  - Use of more Sensors
  - Use of self diagnostic systems
  - Increasing skill level of ship crew

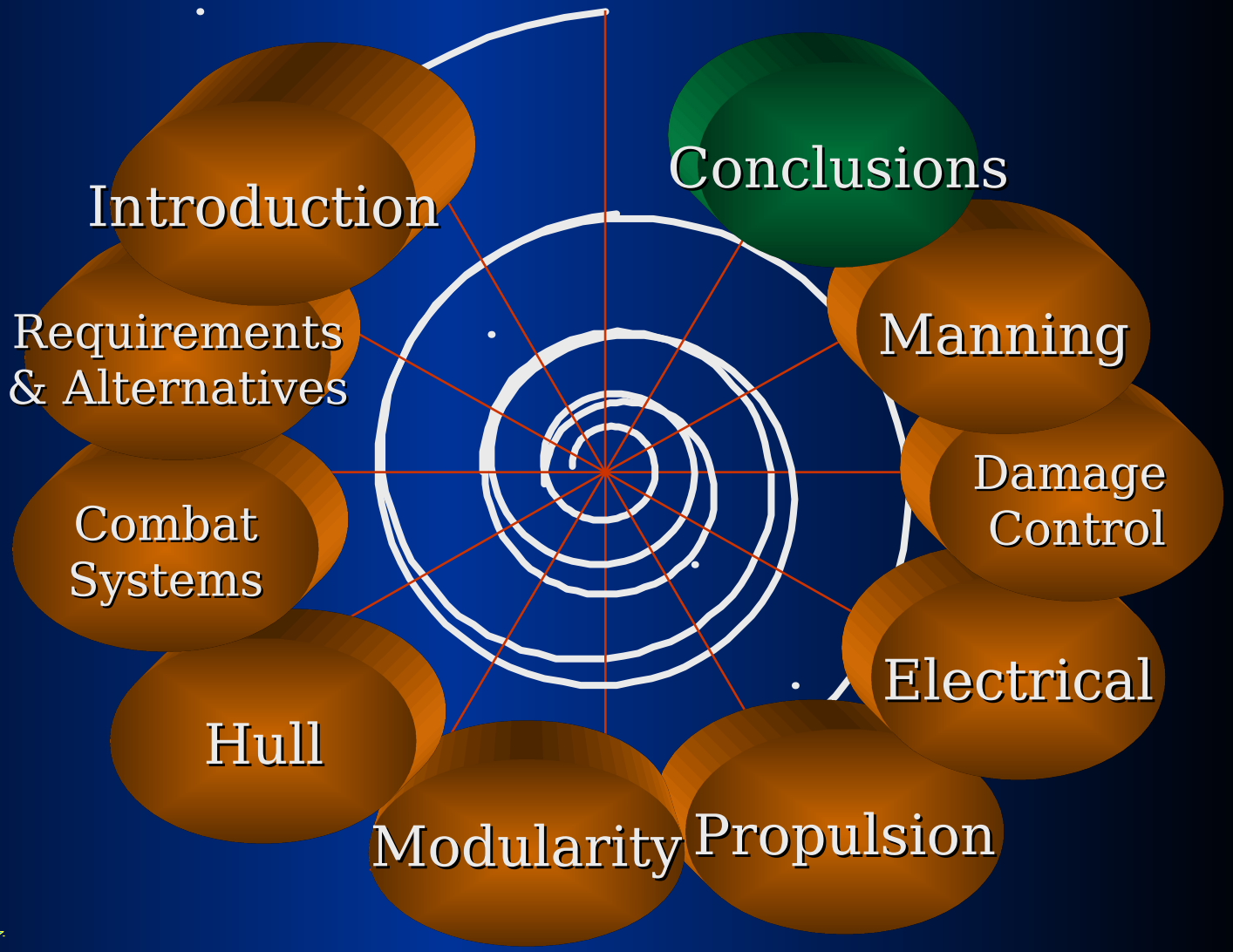
Space Allocation



Space Allocation

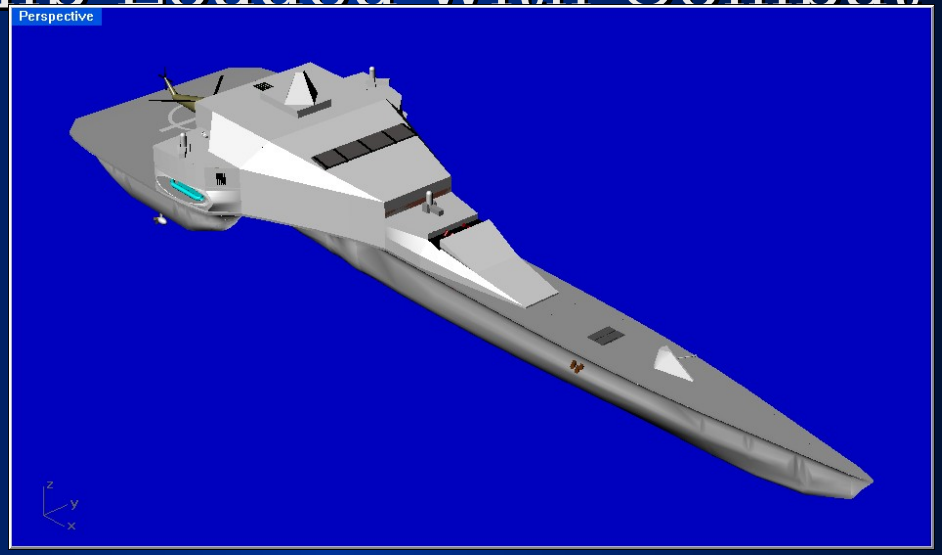


Conclusions



Closing Remarks

- All Requirements Met
- Trade-off Analyses Conducted
- Design Spiral Completed at least once
- Ship Loaded with Combat Systems



Closing Remarks

- Weight Estimations
- Cost ~$655 M
- Hydrostatics
- Environmental Concerns
- Further Pursuits
- http://www.nps.navy.mil/tsse

Conference Room

3rd Deck of MAF Building

1330

Go Navy Beat Army!